A REVIEW OF THE LITERATURE PERTAINING TO THE MODIFIABILITY OF THE INTELLIGENCE QUOTIENT THROUGH ENVIRONMENTAL CHANGES, PARTICULARLY THROUGH CHANGES IN NUTRITIONAL STATUS

by

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CHAPTER I

INTRODUCTION

Origin of the Problem

Dr. Robert R. Williams[1] in 1941, speaking of the part nutrition may play in the improvement of man's being, said,

> The science of nutrition may provide mankind with a tool for consciously controlling and directing its evolution, a process previously governed by cosmic forces outside of man's control.
>
> Perhaps the time has come when we can begin to examine the physical and physiological bases of man's inner urges and begin to elaborate a process of conscious selection which will supplement and perhaps eventually replace the cosmic forces which have heretofore governed the selective forces.
>
> Though our knowledge is as yet fragmentary, one can visualize the possibility that the science of nutrition may furnish a point of departure.

The increasing amount of scientific knowledge concerning the place of nutrition in the improvement of man's physical and mental well-being leads to the question of the place of nutrition in relation to mental ability.

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[1]Robert R. Williams. "Does Nutrition Furnish the Control of Man's Evolution?" Science Digest, I (December, 1941), 48-49.

Reports[2], [3], [4] of the widespread occurrences of malnutrition among the people of the United States of America and those of the prevalence of low intelligence quotients suggest a relationship between these two conditions.

At the time of the first World War, attention was focused on the low intelligence quotients of the soldiers inducted into the armed forces. Reasons for this and means of improving this condition have been sought by educators and scientists throughout the nation.

As an investigation that would be profitable to the author and to those who are interested in the welfare of man, and in the possibilities and responsibilities of education, a study of the literature for evidences of the relationship or a lack of relationship between nutritional status and mental ability was undertaken.

Statement of the Problem

The subject of this study has been stated as:

> "A Review of the Literature Pertaining to the Modifiability of the Intelligence Quotient through Environmental Changes, Particularly through Changes in Nutritional Status."

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[2]L. Epstein. "One Third Ill Fed." Nation, CXLIX (August 19, 1939), 191-193.

[3]John W. Studebaker. "Strong Bodies and Alert Minds." School Life, XXVII (November, 1941), p. 33.

[4]E. Neige Todhunter. "The Evaluation of Nutritional Status." Journal of the American Dietetic Association, XVIII, No. 2, (February, 1942), 79-82.

The primary area of interest in this review is the part nutrition can play in the development of mental ability. In pursuit of this problem some of the questions which presented themselves were:

1. The biological basis of mental ability -- do evidences point to the probability that mental ability can be changed by environmental changes?

2. What are the modern concepts of mental ability as measured by tests? How were these concepts developed?

3. What means are available for judging nutritional status and how were these developed?

4. Does improvement in nutritional status provide a means of consciously promoting the development of mental ability (a) in the individual during his life; (b) of a people over a long period of time, for many generations?

Delimitation

This study does not include experimental work done by the author on the problem under discussion. No attempt has been made to formulate tests or standards for measuring mental ability or nutritional conditions. It is purely a survey and critical analysis of the experimental evidences reported in the literature which refute or support the conclusion that the intelligence quotient can be modified by changes in environmental conditions; of the evidences that nutrition as a part of internal environment can affect the

level of mental ability. An attempt has been made to collect data from the fields of research pertaining to these subjects in order to formulate conclusions regarding them.

Methodology

As a background to the study of the relationship between nutritional status and intelligence quotient, a discussion of research in the fields of genetics, physiology, and biology has been made. Theories concerning inherited characteristics and the power of environment over these have been investigated to find out what relation exists between the construction of the mental processes of the nervous system and both internal and external environment. Experimental evidences of characteristics being changed by environmental influences have been sought. Works by J. H. Robinson, Raymond Dodge, Arnold Gesell, J. G. Needham, H. S. Jennings, I. M. Kugelmass, and others have been reviewed for this discussion.

A more complete review of the research in the fields of education and nutrition covering the development of the methods of measuring mental ability and of measuring nutritional status was necessary. A study of the debate between the advocates of a fixed, unalterable intelligence and the advocates of a variable intelligence quotient led to a review of the experimental evidences which refute or support the conclusion that the intelligence quotient is modifiable.

The studies reported have been evaluated according to the worth of the methods and technics of investigation used.

Authors in the fields of education whose works have been studied include: W. C. Bagley, John Dewey, E. F. Lindquist, R. Pintner, George D. Stoddard, Lewis M. Terman, Edward L. Thorndike, and others.

Authors in the field of nutrition whose works have been reviewed include: J. Goldberger, I. M. Kugelmass, P. B. Mack, C. M. McCay, E. V. McCollum, L. B. Mendel, H. C. Sherman, H. Steenboch, R. J. Williams, and others.

A complete review has also been made of the experimental studies reported in the literature which show evidences of a relationship between mental ability and nutritional status. The methods used in measuring these two factors have been criticized in the light of present knowledge concerning their values as yardsticks of these conditions. These reports are reviewed in detail since it is this relationship that is of primary interest here.

Some of the authors whose experimental work is reported are: E. M. Abernethy, S. Blanton, Franz Boas, D. K. Hallowell, M. C. Hardy, M. A. Hinrichs, C. Hoefer, R. L. Lewy-Guinzberg, D. G. Patterson, W. T. Porter, and L. E. Poull, and others.

Justification

For many years educators have worked with the prob-

lem of the mentally retarded and slow child in an attempt to find the remedy for arrested learning. National, state, and local governments as well as individuals spend large amounts of money for the care and support of those persons whose mental ability makes it impossible for them to be self-supporting. If a means of raising their mental ability could be found, so that they could participate on an equal basis with the rest of the population, money, time, and energy could be saved and contributed to the enlightment and advancement of civilization. Socially, as well as economically, a burden would be lifted if the intelligent quotient could be raised through nutritional means. In a recent report of studies in New York City, Roger J. Williams[5] said that "without question morality and intelligence go together; that the more intelligent a child is, the less likely is his tendency to cheat, lie, and steal, or become delinquent." The possibility of curbing immorality alone is enough incentive for further study of the problem of the place of nutrition in the improvement of mental ability. However, if a people with superior mental ability can be developed by controlling what it eats, much would be done toward the advancement of mankind.

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[5]Roger R. Williams. "Morality and Intelligence." Science Digest, No. I (May, 1942), Front Cover.

Sources of Information

Before beginning the thorough review of the literature involved in this study, a preliminary survey was made to be certain that a study of this kind was not available. Researches[6,7,8,9], in the field of nutrition which were related to the present problem in one factor only were found. This preliminary survey was helpful in locating fruitful sources of data for this study. The Index Guides, Abstract Journals, and Review Journals were most helpful in locating original reports. Experimental work was found reported in Master's and Doctoral Dissertations, in the bulletins of State Colleges and Universities, and in the publications in the following fields:

Child Development
Child Welfare
Education
Endocrinology
Health
Home Economics
Medecine
Nutrition
Physical Education
Psychology
Science

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[6]Karl S. Bernhardt and Ruth Herbert. "A Further Study of Vitamin B_1 Deficiency and Learning with Rats." Journal of Comparative Psychology, XXIV (October, 1937), 263-267.

[7]William C. Biel. "The Effect of Early Inanition upon Maze Learning in the Albino Rat." Comparative Psychology Monograph, XV No. II, (1938), p.33.

[8]Andrew W. Brown. "The Influence of Thyroid Treatment upon the Mental Growth of Cretins." Psychological Bulletin, XXXIV (November, 1937), 777-78.

[9]Arnold Gesell and others. "Effect of Thyroid Therapy on Mental and Physical Growth in Cretinous Infants." American Journal of Diseases of Children, LII (November, 1936), 1117-38.

CHAPTER II

BIOLOGICAL BACKGROUND OF MENTAL ABILITY

In order to study the relationship between mental ability and nutritional status, it was necessary first to investigate the theories of scientists regarding the source and development of mental ability. This chapter deals with psychological and biological concepts of the basis of mental ability, with the relative influences of heredity and environment upon the origin, growth and development of the organism, and with the influences of environment upon the selection and development of characteristics within the organism.

In speaking of the biological basis of mentality, Bagley[10] in 1922 wrote that in the early twentieth century, men thought that mentality depended upon the number of nerve cells in the cerebral cortex, and that fifteen years later it was thought that differences in the readiness of synaptic connections was the physiological basis of differences in mentality. He said that scientists had begun to believe that the readiness of synaptic connections depended upon the stimulating effect of the endocrines, notably the pituitary, the thyroid, and the adrenals. Thus about twenty years ago, mentality was visualized as a function and not a structure as it

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[10] William C. Bagley. Determinism in Education. (York, Pennsylvania: Warwick and York, Inc. 1928), p. 10.

had previously been believed to be. According to Bagley[11] mentality was "the end function of intermediate functions of other functions, which ultimately, we believe, work back to interlocking groups of structures through a maze the complexities of which have so far baffled every effort at analysis."

Gesell[12] in 1928 described mental growth as the emergence of behavior values based on the maturation of the nervous system. He said that the factor of growth potency is probably resident in the protoplasmic plasticity of the individual, but it may be subject to variation by one's endocrine constitution and is conditioned by opportunity, desire, and motivation. It is in a constant process of transformation and of reconstruction.

Robinson[13] in 1921, Dodge[14] in 1931, Needham[15] in 1941, and Kugelmass[16] in 1942 summarized the organization of brain power as the result of the interaction of the millions of neurones which make up the nervous system. They described

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[11]Bagley, op. cit., p. 15.

[12]Arnold Gesell. Infancy and Human Growth. (New York: Macmillan Company, 1938), p. 13.

[13]James H. Robinson. The Mind in the Making. (New York: Harper and Brothers, 1921), 235 pp.

[14]Raymond Dodge. Human Variability. (New Haven, Connecticut: Yale University Press, 1931), 148-162

[15]James J. Needham. About Ourselves. (Lancaster, Pennsylvania: The Jacques Cattell Press, 1941), p. 64.

[16]Isaac N. Kugelmass. Superior Children through Nutrition. (New York: E. P. Dutton and Company, 1942), p. 88.

these neurones as living cells having their own ways of living, consuming food, and developing energy; the nerve cell tips as gateways for the conveyance of impulses; and the final behavior as being determined by the character of each participating link. According to these views every sensory reaction may be traced through the nervous system as a chain of stimuli and reactions to stimulation. Then variability of consciousness may be traced to the elementary processes of neural action.

The dynamic energy required for mental processes, according to Kugelmass[17] may be found in the protoplasmic cells. The author said that these mental processes develop rapidly from mere protoplasm to automatic reflexes, emotional behavior, conscious realization, and finally to reasoning mechanisms.

Needham[18] in 1941, in describing the development of brain power, said,

> All brain power rests on a basis of organized reflexes. Superadded to reflex activities, three types of nervous action appear to have been successively attained, and they are reacquired by the individual in his own time and in something of a necessary sequence:
>
> 1- The power to retain and recall the effects of past experiences; in a word, memory: power to recall automatically and instantly, not only the action that followed upon a particular stimulus, but also the resulting consequences of that act.

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[17]Kuglemass, op. cit., p.87.

[18]Needham, op. cit., p.80.

2- The power to discriminate between stimuli as to their relative importance, and to forestall response to those that might lead to improper action.

3- The power to initiate new modes of action in absence of external stimulation, and thus gain new experience. This last is the key of entrance to the realm of intellectual supremacy.

Since the best knowledge of today leads to the conclusion that brain power is determined by the harmonious functioning of the nervous system and since the nervous system is dependent upon the development of the entire organism, the following questions concerning the growth and development of the organism and the factors influencing its growth arise:

1- Upon what is the activity of the organism dependent?

2- To what extent is this activity dependent upon its inherited characteristics?

3- Is environment a force which may determine which characteristics shall develop in the present generation?

4- Can environment influence the choice of characteristics which shall be transmitted to the future generation?

In an attempt to answer the first question, Jennings[19] may be cited. In speaking of the development of an organism, he has said that what happens in any object in its development depends upon the material of which it is composed and upon the conditions under which it is found. He said that man receives

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[19]Herbert S. Jennings. Promotheus. (New York: E. P. Dutton and Company, 1925), 13-75.

packets of diverse chemicals from his parents; that these packets are known as chromosomes and are arranged in a definite way so that the young organism is like a well-organized chemical laboratory with many reagents that react orderly with one another and produce a harmonious result. He stated that the products of the chromosomal genes are chemicals that may be made, modified, and moved about as other chemicals; and that, since there is no 'priori' reason why shortcomings due to defective genes might not be remedied as are other factors, an unlimited field for progress in the control of development is open.

Jennings stated that the production of any characteristic is dependent upon both an adequate stock of chemicals and an environment adequate to produce the characteristic. The proper interaction of these chemicals with one another and other things, with the cell body or cytoplasm, and with chemicals brought into the cell from the outside, and the influences of the physical agents of the environment produce the characteristic. A change in any of these factors may change the result, according to the author.

What man knows today about the functioning of his mind and body has been largely learned from the study of lower animals. To illustrate the extent to which environment may affect inherited characteristics and alter the entire organism, Jennings described the changes which take place in the fruit fly in response to changes in its environ-

ment. If kept properly warm, the fruit fly, which normally produces supernumerary legs, ceases to produce so many. In the case of the salamander, which the author reviewed, the environment so affected the organism that the physical characteristics were changed and the new characteristics were transmitted to the offspring. The salamander, while living in the water, had a broad, heavy body, a tail flattened for swimming and external gills; but as the environment was changed an entirely new set of characteristics was developed. On being taken out of the water, the salamander's body became smaller, slender, and of a different shape. Its external gills disappeared and the animal had no trouble living on land. These new characteristics were found in the next generation of salamanders.

To further illustrate that development is a continual adjustment to environment, Jennings referred to the case of frogs. He said that these animals begin with a single cell which divides into two cells, one of which usually produces the right half of the body and the other usually produces the left half of the body. But if these cells are separated, each produces an entire animal.

As in the case of the lower animals, so with man environment may be a determining factor in the selection of characteristics which shall develop. Jennings said that the lot of individuals and society is enormously alterable and improvable by changes in conditions, by invention, by increase

and dissemination of knowledge. Environment decides which of the many sets of inherited characteristics of man shall be developed. As conditions become easier, combinations of genes that would have otherwise been eliminated, survive, develop, and propagate. The educated man has characteristics very diverse from those he would possess if he were uneducated and his educated characteristics are just as truly native and inherited as any he has, for all his characteristics depend upon the conditions under which he develops, and would be different under varying conditions.

The question as to whether the characteristic of intelligence is due entirely to inherent capacity or to a great degree to the influences of the environment is of primary interest in this investigation. Colvin[20] in 1922, in discussing this question wrote that the two must work jointly and are dependent upon each other for the fullest expression of their potentialities. He brought out the point that the feeble-minded child can never become highly intelligent no matter how favorable his environment is, while on the other hand, the greatest potential intelligence will never become highly intelligent in an environment that affords scant opportunity to learn. That intelligence is not wholly dependent upon physical heredity is seen in the advanced

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[20]Stephen S. Colvin. "Principles Underlying the Construction and Use of Intelligence Tests." Twenty-first Yearbook of the National Society for the Study of Education, (Bloomington, Illinois: Public School Publishing Company, 1922), p. 18.

social development of the present man in contrast to the paleolithic man. If native intelligence were much the superior force as compared with culture, one would expect to find man in all periods of history employing the same improvements in the conditions of life that the more advanced civilizations use. But evidence points to the continuity of culture and the consolidation and accumulation of the benefits of experience in lifting mankind from the paleolithic levels.

Needham[21] in 1941 gave substantially the same idea concerning the nature and nurture of individual intelligence. He said that the nature of the individual is dependent upon its innate hereditary tendencies but that its nurture, supplied by the internal and external forces of environment, provide the conditions that will permit the development of the potentiality of nature. He compared the barbarian and the city man who, according to Needham, are zoologically alike in that they have the same manner of birth and development, appetities and instincts but differ in that they do not have the same brain. The author attributed the differences between the modern man and the best stone age man to the influences of social nurture. He said that the same was true of the differences between Michael Angelo and the savage who first made crude pictures on the walls of his

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[21]Needham, op. cit., 125-133.

cave. Angelo had the advantages of long training, better tools, and an artistic social background.

The attempts to analyze the relative amounts of individual ability due to nature and those that are due to nurture have failed because of the complexity of the situation. The innumerable factors of environment will have to be determined and measured quantitatively before the problem can be answered. But there are sufficient evidences to warrant the conclusion that environment is a very important factor in the development of the potentialities of individual intelligence.

Since this is true, it would be well to see how environment is defined by investigators. Warren[22] in 1934 defined environment as a term covering all physio-chemical, biological, and social phenomenon which act upon the organism from without and influence its structure or its behavior. In 1940 Wellman[23] defined internal environment as those energies inside the outer skin of the organism that act upon the internal sense organs or receptors. Mechanical changes in muscle and chemical changes in food substances in the alimentary canal are examples of such internal environmental

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[22]Howard C. Warren. Dictionary of Psychology. (Boston: Houghton Mifflin Company, 1934), p.93.

[23]Beth L. Wellman. "The Meaning of Environment." Thirty-ninth Yearbook of the National Society for the Study of Education, (Bloomington, Illinois: Public School Publishing Company, 1940), p. 22.

energies. Changes in the blood stream are effective, according to Wellman, in altering the activity of the total organism because such changes affect the sense organs, the nervous system, and the muscles.

The part of the environment that is most important in this study is the factor of internal chemistry. It is also important to know what part food plays in the chemistry of the body. It is obvious that the major part of the chemicals which supply the body must come from the food consumed by the individual. As Sherman[24] has said, "Life processes are chemically connected in known and fairly direct ways with food." Kugelmass[25] said that fifty nutrients are released from edible foods by digestive processes in order to be transformed into material native to the organism.

Since food has a definite determining influence upon the functioning of the body, it is reasonable to assume that food will influence the mental behavior of an individual in the proportion that the proper functioning of the body determines the mental behavior.

Summary:

It has been shown that mental ability is determined

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[24]Henry C. Sherman. Chemistry of Food. (New York: Macmillan Company, 1938), p.5.

[25]Isaac N. Kugelmass. Superior Children through Nutrition. (New York: E. P. Dutton and Company, 1942), p.1.

by the growth and maturation of the nervous system; that the behavior pattern of an organism is the product of the interaction of its inherent characteristics and the agents of the external and internal environment; that development is a continual process of adjustment to environment; that environment determines which of the inherited potentialities of an individual shall be developed; and that food intake as the source of the chemicals of the body has an important part in the growth and activity of the nervous system and consequently in the development of mental ability.

The possibility of the environment being a factor in the improvement of future generations has been mentioned by such men as Jennings and Williams. Whether or not environment can change the inherited potentialities of future generations remains to be proved, but without question there are evidences that the factors of improved social environment increase the development of the potentialities of the individual. It is not a prohibited hypothesis that improved health and body condition due to proper food may act as a selective factor in the development and transmission of characteristics from one generation to another.

CHAPTER III

CONCEPT OF INTELLIGENCE QUOTIENT AND ITS USE AS A MEASURE OF MENTAL ABILITY

Since it has been shown that mental ability can be influenced by external and internal environment, the question of the extent of these influences and that of the nature of the agents arise. However, in order to make a study of these problems, it is necessary to know first how mental ability is measured and the limitations of the procedures used in the measurements. Therefore, the meaning of "intelligence" and the methods and means by which it has been measured have been reviewed.

In 1905 Binet[26], the French psychologist, thought of intelligence as a complex process determining the individual's capacity to think along a definite direction, to make adaptations to a given end, and to judge or criticize the solutions found thereby.

In 1914 Stern[27] said, "Intelligence is general adaptability to new problems and conditions of life."

At the same time Thorndike[28] gave his idea of intelligence as the sum total of specific abilities: that the

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[26]George D. Stoddard. The Meaning of Intelligence. (New York: Macmillan Company, 1940), p.3.

[27]W. Stern. "The Psychological Methods of Measuring Intelligence." Educational Psychology Monograph, No. 13, 1914.

[28]Edward L. Thorndike. Educational Psychology. (New York: Teacher's College, Columbia University, III, 1914), 358-371.

quality of intellect depends upon the quality of connections of the nervous system; and the degree of his intellect is indicated by a man's power to respond correctly and profitably to certain stimuli and situations. In judging whether behavior is intelligent or not the author estimated behavior from the standpoint of its value to the individual. Freeman[29] in 1940 seconded Thorndike's criterion for judging intelligent behavior. To them a higher ability meant doing a thing in a way better suited to attain an end than is done by some other method. An intelligent act in general, they state, is one that the individual has learned to perform and that better enables him to meet his needs and to satisfy his desires than he would be able to do by some other act.

The measurement of behavior from this standpoint is difficult because of the inability of investigators to see the entire picture of a subject's needs and activities upon which the value of an act is based. What to the subject might be considered the best solution of a problem to another might appear of questionable value.

In attempting to judge behavior from the standpoint of intelligent activity several methods were used. Prior to the late nineteenth and early twentieth centuries, people relied upon personal judgments and evaluations of the com-

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[29]Frank Freeman. "The Meaning of Intelligence." Thirty-ninth Yearbook of the National Society for the Study of Education, Pt. I. (Bloomington, Illinois: Public School Publishing Company, 1940), p. 6.

parative brightness or dullness of children for estimating intelligence. Teachers were inclined to think that the better behaved children were brighter than those who misbehaved. These means of estimating behavior have been replaced with more objective methods of measurement in the form of "Intelligence Tests".

The following is a review of the development of intelligence tests but does not contain a complete history of the field. It includes, rather, a sampling of the names and types of tests which have been formulated, of the terms employed in evaluation of the results of the tests, and a discussion of the value of the IQ as a measure of intelligence.

About forty years ago, psychologists, especially in France and Germany, began to study the problem of measuring intelligence. Realizing the wide range of abilities represented in man's activities, they began to attack their problem by making normative standards of the higher thought processes. Data on the performance of large groups of individuals in given situations was used in making these normative standards. Individual performance was judged in comparison with the norms.

Binet[30], who did the first important work in intelligence testing, prepared a standardized interview which called upon the child's ability to get a problem clearly in mind, to

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[30]Stoddard, op. cit., p. 94.

make mental adaptations, and to do abstract reasoning. Success in school was used as a criterion for the validation of these tests. Vocabulary and language tests were found useful in judging ability because they utilized aspects of the child's previous learning. This kind of test measured individual differences in learning ability. Binet formulated his general intelligence tests in 1905 with Simon as collaborator.[31] The same workers revised these in 1908 and again in 1911.

In 1916 Terman[32] revised and extended the Binet-Simon tests so that they were applicable for general educational purposes. This was the first great improvement over the Binet tests and is called the "Stanford Revision of the Binet-Simon Scale." Other modifications of the Binet-Simon tests, which were used to measure the intelligence of individuals, were the Kuhlmann[33] and the Herring revisions.

Group tests were next formulated by adapting the material of the Stanford Revision to groups of individuals and by adding new tests. An example of these is the Otis Scale. The need, for military purposes, of selecting and classifying recruits from a mental standpoint as well as from a physical one, led to the development of the Army Alpha and Beta tests.

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[31]Stoddard, op. cit., p. 95.

[32]Lewis M. Terman. The Measurement of Intelligence. (Boston: Houghton Mifflin Company, 1919), 51-64.

[33]Frederick Kuhlmann. Tests of Mental Development. (Minneapolis, Minnesota: Educational Test Bureau, 1939), 314 pp

The demand of educators for measures of intelligence that could be given to groups of children was answered by the Otis, Thurstone, Miller, Thorndike, Anderson, Brown, Pressey, National, and Terman tests.

Non-language examinations such as the Army Beta, the Pintner, and the Myers are given to small children, foreigners, and illiterates. The Otis, Army Alpha, Thurstone, Haggerty, and National are also used for group testing but involve language abilities.

In evaluating performance on these tests, the ability of the subject is measured in comparison with others of like age. Some of the terms used in stating the findings of the tests are explained here. The "Mental Age" of an individual is obtained by rating his performance in terms of the chronological age of the year group whose median performance in the test equals the subject's. Thus, if a child of twelve attains the mental ability comparable to that of a group of thirteen year olds, his mental age is thirteen. The "Intelligence Quotient"* is obtained by using the mental age and the chronological age of the subject in the following formula:

$$IQ = \frac{M.A.}{C.A.} \times 100.$$

Thus in the case above, the child's IQ would be 108.

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* In the remainder of this paper "Intelligence Quotient" will be designated as IQ, an accepted abbreviation for this term.

IQ ratings have been arbitrarily classified into groups varying upward and downward from the average level of performance. These classes are not homogenous, nor are there gaps between the classes. Terman in 1916 gave the following classification of these ratings:[34]

Classification		Score (IQ)
Genius, or near genius		Above 140
Very Superior		120-140
Superior		110-120
Normal or Average		90-110
Dull or Backward		80-90
Borderline deficiency		70-80
Definitely feeble-minded:	(a) Moron	50-70
	(b) Imbecile	20-50
	(c) Idiot	Below 20

Thus the "Distribution of Intelligence" appears to conform to a normal curve. A large percentage of cases fall in the normal or average class; the number of cases in the superior and subnormal classes are practically even, and as the deviation from the median increases, the number of cases gradually decreases.

The value and use of the intelligence tests as true measures of mental ability have been subjects of controversy

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[34]Lewis M. Terman. The Measurement of Intelligence. (Boston: Houghton Mifflin Company, 1916), p.79.

by many educators. According to Terman[35], intelligence testing carries some danger of misinterpretation; but this can be avoided by insisting on highly trained examiners, and by using the obtained mental age and the IQ not as ends in themselves but as useful guides to the child's development and education.

Stoddard[36] said that the importance of the IQ at any age level has likely been overestimated since the knowledge of the child's ability obtained from an analysis of academic records, when the conditions of teaching and examining are good, is comparable to that gained from IQ ratings. The author had the opinion that intelligence tests are to a considerable degree simply knowledge tests scored relatively to the achievement of like-age children. He said that correlations have been tested between the results of these tests and school grading and have been found relatively low, but this may be due to faulty methods of school grading and lack of uniformity in school marks. He contended that when educators cease to keep bright children below the level of their ability in school, and when they refrain from pushing the dull child above his ability, and when sufficient con-

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[35]Terman, op. cit., 49-50.

[36]George D. Stoddard. "Some Preliminary Comments upon the Nature and Nurture of the IQ." Thirty-ninth Yearbook of National Society for the Study of Education, Pt.I. (Bloomington, Illinois: Public School Publishing Company, 1940), p.6.

secutive and scientific records of individual growth are available which will help to place children in the proper grade, a higher correlation between scores on intelligence tests and scholastic achievement will probably be the result.

Dewey[37] values the IQ, as it is measured by present methods, as an indication of certain risks and probabilities. He feels that its present practical value lies in the stimulus it gives to more intimate and intensive inquiry into individual abilities and disabilities; that the proper goal of mental testing should be "a method of discrimination, of analysis of human beings, of diagnosis of persons, which is both intrinsic and absolute, not comparative and common." To reach this goal it is necessary to have statistical norms which are of value in working out a system of tests to be used ultimately in the analysis of the individual. For example, the testing of a particular trait in a particular person is measured by the manner in which large numbers react to similar exercises. Individual capacities and limits may not be known until experience, that is education, is broadened to reveal all the potentialities of that individual.

Colvin[38] has said that the IQ may be said to be a

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[37]John Dewey. Character and Events. (New York: Henry Holt and Company Inc., 1929), II, Bk. III, p. 483.

[38]Stephen S. Colvin. "Principles Underlying the Construction and Use of Intelligence Tests." Twenty-first Yearbook of the National Society for the Study of Education. (Bloomington, Illinois: Public School Publishing Company, 1922), p. 19.

measure of the development of the intelligence of an individual; that when mental tests are based on elements involving experiences common to those tested, they will measure capacities indirectly through what has been acquired, but never in their native purity. However, we infer from differences in acquired intelligence differences in native endowment when the comparison is made of individuals who have had common experiences. Another item that is important in the effectiveness of the tests is the opportunity that has been given the subjects to learn the items tested and the subjects' desire when the opportunity is given.

Binet warned against the use of intelligence test ratings as an automatic method of stamping individual ability. He saw the disadvantages of the system which would arise from misinterpreting the results and advocated their use as guiding factors in formulating plans for the educational approach to the individual rather than as measures of unmodifiable intelligence.[39]

Summary:

Attempts to measure intelligence by objective tests began when Binet formulated his general intelligence tests in 1905. Succeeding educators have contributed to this move-

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[39]George D. Stoddard. Intelligence Testing. Studies in Child Welfare, n. s. 658, No. 9, (Iowa City: University of Iowa, October 22, 1932), p.4.

ment with tests which measure both general and specific ability. The results of these tests have been used to determine the mental age of those taking them. The mental age is obtained by rating the individual performance on tests in terms of the chronological age of the year group whose median performance in the test equals the subject's. The mental age is used in determining the IQ, which expresses the ratio of the mental age to the chronological age. The following formula may be used:

$$IQ = \frac{M.A.}{C.A.} \times 100.$$

Some controversy as to the value and use of intelligence tests and their results as a measure of mental ability has arisen. It is generally agreed that the tests measure acquired knowledge and skill, and from differences in these, when a comparison is made of individuals who have had common experiences, differences in native ability are inferred. But it cannot be inferred that total potentiality is measured by any one test or group of tests. Factors which alter behavior on tests will be discussed in a later chapter.

The value of the IQ lies in the approach it provides to the understanding of the status of an individual whereby an intelligent plan of guidance in education may be made. It affords insight into individual differences in ability to make functional adaptations.

Although these tests do not measure total mental ability or potentialities, they constitute the best available

method of measuring intelligence and by using a series of tests covering a wide range of material, and by giving repeated tests over a long period of time, scores accurate enough for all practical purposes may be obtained. Therefore, their continued use until replaced by more exact and reliable methods will be justified.

CHAPTER IV

EVIDENCES OF THE MODIFIABILITY OF THE INTELLIGENCE QUOTIENT

With the growth of the measurement program in education came a controversy as to the place the results of intelligence tests should have in judging the potentialities of individual ability. Some students of the problem believed that the IQ was a measure of the total native ability of an individual and that it was static and unchangeable because it was predetermined exclusively by factors of heredity. Other students of the problem believed that the IQ was a measure of the degree of development of potential ability, the extent of the development being due jointly to inherited ability and to the influence of environment upon the individual. This chapter deals with the theories of the advocates of determinism concerning the implications of the IQ and with the theories of the advocates of a changing, developing IQ. A review is also made of evidences of the modifiability of the IQ.

In spite of Binet's warning against the misuse of the results of intelligence tests, the ratings derived from these tests were accepted by some as total pictures of an individual's potentiality. Thus they were used to support the hereditarian view that intelligence is fixed, certain, and predetermined for an individual at the time of his advent

into this world. In 1919 Terman advocated the use of the IQ as a basis for the prediction of an individual's future success or failure. He did not think that environmental factors would cause the development of the inherited characteristics to vary appreciably. The extent to which he would use the IQ in predicting future attainment was shown in the following paragraph[40]:

> The relative permanence of the IQ enables us to predict with some degree of approximation the mental level a child will attain by a given age... Facts have been presented which show that the limits of a child's educability can be fairly predicted by means of mental tests given in the first school year. By repeated tests these limits can be determined accurately enough for all practical purposes by the end of the child's fifth or sixth school year. This early, at least, vocational training and vocational guidance should begin.

Colvin[41] in 1922 saw that there was a prevalent conviction that the influences of education were very narrowly circumscribed by traits or capacities which, for each individual, are both innate and unmodifiable by experience or training.

Bagley[42] in 1928 called attention to the extent to which the determinists would use the fatalistic implications

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[40]Lewis M. Terman. The Intelligence of School Children. (Boston: Houghton Mifflin Company, 1916), 157-158.

[41]Stephen S. Colvin. "Principles Underlying the Construction and Use of Intelligence Tests." Twenty-first Yearbook of the National Society for the Study of Education. (Bloomington, Illinois: Public School Publishing Company, 1922), 11-44.

[42]William C. Bagley. Determinism in Education. (York, Pennsylvania: Warwick and York, Inc., 1928), p. 13.

of their interpretation of intelligence ratings. He said that they would limit education to those children who, as evidenced by intelligence ratings determined between the ages of three and twelve years, are fit for further education; and would use vocational tests to determine which field an individual was best suited for so that he might be placed therein. He quoted from a 1922 English Education Journal:

> "The Pall Mall Gazette has made the discovery (on the authority of Dr. R. R. Rusk, lecturer on education to St. Andrews University) that seventy percent of the children of this country will never develop any more intelligence than that which should be possessed at the age of fourteen, and, consequently, further education is wasted on them. Of the remaining thirty 'only four will be found fit to take an Honours degree at the University.' "
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> "This 'discovery', the result we are told, of psychological tests made upon children in America, Germany, and Scotland (but not apparently in England) has suggested to the Pall Mall's correspondent a method whereby 'education will be improved and, at the same time, expenditure decreased.' In the future a series of tests applied to each child between the ages of three and twelve will enable the authorities to know exactly which of them is fit for further continued education..."

Dewey[43] in 1929 called attention to the tendency of the American people to accept the fatalistic view of the implications of the IQ. He said,

> We welcome a procedure which under the title of science sinks the individual into a numerical class; judges him with reference to capacity to fit into a number of vocations ranked according to present business standards ; assigns him to a predestined

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[43]John Dewey. Character and Events. II, Bk. III. (New York: Henry Holt and Company Inc., 1929), p. 488.

niche and thereby does whatever education can do to perpetuate the present order.

From these illustrations it is apparent that the determinists would close the channels of intellectual education to an individual after he reaches the limits of his educability as determined by the use of intelligence tests. This concept does not recognize that the development of mental ability might vary in response to the stimulating activities of the infinite experiences of life.

On the other side of the picture are the non-determinists who consider the IQ to be a measure of the development of the intelligence of an individual. They predict that mental ability will vary according to the inherited ability and in relation to the advantages afforded by the environment.

Bayley[44] attributed the sanction which the results of intelligence testing seemed to give to the deterministic view of intelligence to the interpretation of the results rather than to the facts revealed by the measurements.

Recent studies in which repeated tests of individuals have disclosed evidence of inconstant IQ's and of wide individual variation from the mean curve in the rates of growth have been reviewed. Wellman has done a great deal of experi-

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[44]Nancy Bayley. "Mental and Motor Development from Two to Twelve Years." Review of Educational Research, IX (November, 1939), p. 18.

mental work at the Iowa State University Preschool Laboratories concerning the variability of the IQ. She[45] attributed variance in IQ's not only to hereditary factors but also to differential constitutional factors not carried in the genes, such as prenatal malnutrition; environmental factors related to nutrition, endocrine functioning, and metabolism; and chance factors undetermined by any known conditions. She[46] thought that changes in the individual child produced by environmental factors depend upon the nature of the child and the value of the environment for mental stimulation. The amount of shift in IQ will depend somewhat upon how high it was in the beginning. Theoretically, if the child's IQ is as high as the environment is capable of producing in him, there will be no increase; if lower, there will be an increase; if the environment is a depressing one, the IQ will drop and the amount of the drop will be greater if his initial IQ was higher. The author recognized the limits to development which structural defects of the brain and nervous tissue serious enough to interfere with mental functioning place on the growth of individual intelligence. Two individuals of seventy IQ might present entirely different possibilities for further changes, the one having reached his top level, the other presenting various possibilities for either up-

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[45]Beth L. Wellman. "The Meaning of Environment." Thirty-ninth Yearbook of the National Society for the Study of Education, Pt. I. (Bloomington, Illinois: Public School Publishing Company, 1940), p.32.

[46]Ibid., 36-37.

ward or downward changes depending upon the ingredients of the environment and their adaptations to his particular needs.

In measuring the effects of environment upon the IQ, Wellman[47] suggests one of the following methods be used:

First- a longitudinal study of changes in IQ over a specific period under specific environmental conditions; or,

Second- a cross-sectional analysis of the relative proportions of a child's IQ that are attributable to heredity and to environment.

In the recent studies to measure the effect of environmental factors on the IQ, increasing effort is made to control the age and interval differences in testing, and to report longitudinal studies in which the same children have been tested repeatedly at regular intervals over a fairly long time.

Among these studies is work reported in the "Studies in Child Welfare" published by the University of Iowa. Wellman is one of the outstanding workers there. In 1934 Wellman[48] found that the curves in the rates of mental growth of children from the Iowa Preschool Laboratories who had been tested repeatedly from preschool to college showed wide variations.

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[47] Wellman, op. cit., p. 30.

[48] Beth L. Wellman. "Mental Growth from Preschool to College." Journal of Experimental Education, VI (December, 1937), 127-38.

In 1936 Lincoln[49] at Harvard made a study of data collected over a period of seven years from a study of IQ changes in 1200 children. Two or three tests were given each child. The author recognized the limitations of his study because the children did not comprise a completely representative sampling of children from normal or average groups because most of them were from better than normal intellectual groups.

In this study the first IQ's were recorded and subsequent IQ differences were regarded as changes from the first. The results for the boys were separated from the results for the girls because previous studies had indicated that real sex differences may exist. The data showed 1,804 IQ changes for boys and 1,645 IQ changes for girls. The median differences for the boys was 7.35 IQ points and for the girls it was 7.17 IQ points. The boys showed 52.7% of the changes were gains, with a median change of 8.53 points while the boys' losses showed a median of 6.85 points. The girls showed gains in 48.3% of the cases with a median gain of 7.92 points; their losses showed a median of 7.13 points. From these figures the author concluded that boys gain more often than girls and their gains are larger.

When the results were separated according to IQ levels

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[49] Edward A. Lincoln. "Stanford-Binet IQ Changes in the Harvard Growth Study." Journal of Applied Psychology, XX (February, 1936), 236-242.

it was found that there was a steady increase in size of median differences from the "Very Inferior" to the "Very Superior" group. The implications were that "Very Inferior" IQ's are most consistent.

The author stated[50] that, "Differences are interesting statistically, but it is doubtful whether they have any practical significance."

Pintner and Stanton[51] in 1937 used Thorndike's CAVD Test in studying the growth of intelligence of a number of New York City public school children from the first to the eighth grades. This test was given annually to 140 children. Varying numbers of the children carried through from two to six years of the study. The initial average IQ of the group was around 100 IQ. The authors found a total of 364 gains or losses from one year to the next. The average gain was 1.06 IQ points with a standard deviation of 0.71. Only thirty-four percent showed losses. The largest loss was 1.08 points and the greatest gains occurring in fourteen cases were 2.5 points or more. This average gain of 1.06 IQ points according to Thorndike's scale is equivalent to about one and one-half years of age. There seemed to be a slight decrease in the average gain from year to year. Those who had scored

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[50] Lincoln, op. cit., p. 239.

[51] Rudolf Pintner and Mildren Stanton. "Repeated Tests with the ACVD Scale." Journal of Educational Psychology, XXVII (October, 1937), 494-500.

low made relatively large gains during the first year but thereafter did not make such large gains. Those who made high scores in the beginning made their largest gains in the second year.

These differences in IQ's are interesting and point to the probability of changing mental ability but the changes are not great enough to establish a significant critical ratio.

Table of IQ Changes as Shown in the Pintner and Stanton Study

Total cases	364	Extreme range	- 1.8 to + 3.5
Average gain	1.06	Middle 50%	+ 0.5 to + 1.4
S. D.	.71	Middle 80%	+ 0.2 to + 1.9

Bayley and Jones[52] in 1937 made individual mental growth curves for 61 children tested from birth to four and one-half years of age. The study was made on the effects of environmental factors such as education of the parents and the socio-economic status of the family on the mental and motor achievement of the children. The California Preschool Scale I was given each child twelve times during the age period of eighteen months to twenty-six months. The Stanford-Binet intelligence test was given at the age of six years. The curves of mental growth showed inconstant rates of growth.

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[52] Nancy Bayley and Harold E. Jones. "Environmental Correlates of Mental and Motor Development", Child Development, VIII (December, 1937), 329-341.

The results showed that future intellectual ability can not be predicted by test performance in the first eighteen months of life. The early mental test performance was uncorrelated with mental scores made two years later. This was attributed to an increasing manifestation of hereditary potentialities and to assimilation of environmental pressure.

Freeman and Flory[53] in 1937 reported a study of 469 children who had been tested at yearly intervals between the ages of eight and seventeen years. A carefully selected battery of tests was used involving graded increases in difficulty over the age-range studied. The authors found large and consistent individual differences in the rates of growth of mental ability among the children tested over a period of six to ten years. The correlations between tests given five to ten years apart are so low that it was obvious that adequate prediction of later ability can not be made from tests given at early ages.

In her reports of a study made in 1938 in which Merrill-Palmer IQ's were calculated and checked by using Binet ratings, Wellman[54] cited significant changes in IQ's. The

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[53]Frank Freeman and Charles D. Flory. "Growth in Intellectual Ability as Measured by Repeated Tests." Monograph of the Society for Research in Child Development, II, No. 2, (Washington, D. C.: National Research Council, 1937), p. 77.

[54]Beth L. Wellman. The Intelligence of Preschool Children as Measured by the Merrill-Palmer Scale of Performance Tests. Studies in Child Welfare, XV No.3. (Iowa City: University of Iowa, October 1, 1938), p. 44.

data upon which this study was based consisted of the results of 510 Merrill-Palmer tests given 281 children and checked throughout by Kuhlmann and Stanford-Binet tests of the same children. By careful analysis Wellman was able to differentiate between the practise effects and real changes in scores indicative of increased ability. She regarded the effect of attendance in the preschools of the Station to be a reliable acceleration in mental growth. Her findings include the following:

Gains of approximately five IQ points may be expected on on a retest at an interval of six months.

Children attending the preschool laboratories at Iowa City were found to make gains in IQ over and above the gains to be expected from repetition of the test. Gains made over the winter months when attending preschool were approximately twice the size of the gains made over the summer months, the interval being the same. The difference in gains was attributed to the effects of preschool attendance.

Seventy-two cases having a test in the fall and a retest in the spring gained 9.1 IQ points. This gain is significant since the ratio of the difference to the standard deviation of the difference is 3.37.

Forty-two cases having a test in the fall and their second test in the spring gained 10.17 IQ points, a significant gain, with a ratio of 3.35.

Forty-six cases having their first test in the spring

and their second test in the fall gained 5.2 IQ points over the summer. This difference is not significant, the ratio being 0.97 or 83 chances in 100 that the gain is true.

Gains over the winter months were usually twice the gains over the summer months. In most instances the gains over the winter months were statistically significant or approached significance, all but one ration being 2.4 or above while the summer ratio was never over 1.14. The only definitely known condition that varied with these periods was the preschool attendance.

Wellman[55] again, in 1939, reported a study giving examples of children entering preschool with average intelligence who, after especially favorable circumstances, later tested at "genius" levels. Illustrations of changes in IQ in an upward direction were given. One child tested 89 at three years of age, 149 at ten and one-half years, and 132 at thirteen and one-half years. The IQ's of two other children tested at three and one-half years of age were 98. One of these moved rapidly upward to 167 at five years of age, the other moved upward by progressive steps to 153 at ten years of age. All of these children ranked in the top one percentile on the Council on Education Intelligence tests in high school. All three were in the top ten percentile on college entrance examtions. These represent extreme upward changes found. In

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[55]Beth L. Wellman. "The Changing Concept of the IQ." Journal of Home Economics, XXXI (1939), 77-80.

studies made on about one thousand children attending the Iowa State Preschool Laboratories, Wellman found general IQ increases of five to eight points in any one year. A greater gain was made by some who attended for two consecutive years. Over the summer the IQ's did not change. The author[56] reported that children of similar ability who did not attend preschool did not make similar gains in IQ.

On the other side of the picture, Skeels and his co-workers[57] gave evidences of large decrease in IQ due to unfavorable environmental conditions. Two groups of orphanage children of preschool age were studied. One group was an experimental one and was introduced to preschool education. The other group remained in the customary orphanage environment. This environment was not stimulating and play material was not plentiful. There was a minimum of experiences common to children living at home and receiving personal attention. At the beginning of the study the groups were matched according to IQ, age, sex, length of time in the home, nutritional status, and sensory defects. Those children who did not attend nursery school, regardless of whether their initial IQ classification was average, dull-normal, or border-line, after

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[56]Beth L. Wellman. "Growth in Intelligence under Differing School Environments." Journal of Experimental Education, III, (December, 1934), 59-83.

[57]Harold M. Skeels and others. A Study of Environmental Stimulation. Studies in Child Welfare, XV, No.4. (Iowa City: University of Iowa, December 1, 1938), p. 175.

a period of two years had a final IQ of 75 or slightly over feeble-mindedness. The other group of children did not decrease in IQ although the only difference in their training from the first group was their class attendance in the nursery school.

This group of Iowa studies was vigorously challenged by Simpson[58] in 1939. He claimed that the significance of these studies of the "wandering IQ" was completely obscured by ambiguities and inconsistencies in tabular data, failure to report individual scores year by year, and failure to allow for selective factors in school-leavers. He also criticised the results by saying that rises in IQ mean nothing more than the survival of the fittest.

Wellman[59] replied to simpson's interpretations of her reports and cited the increases found in the Merrill-Palmer study of 1938. These studies were calculated individually as well as by groups and the gains in IQ were well above the expected gains for growth and prctice effects on retests.

Goodenough and Maurer[60] in 1940 belittled the results

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[58]Benjamin R. Simpson. "The Wandering IQ: Is It Time for It to Settle Down?" Journal of Psychology, VII (April, 1939), 351-367.

[59]Beth L. Wellman. "The I.Q.: A Reply." Journal of Psychology, VII (July, 1939), 143-155.

[60]Florence Goodenough and Katharine Maurer. "The Relative Potency of the Nursery School and the Statistical Laboratory in Boosting the IQ." Journal of Educational Psychology, XXXI (1940), 541-549.

of the Iowa studies when they concluded that the statistical laboratory had played a far greater part in affecting the "intelligence" of children than had the Iowa Nursery School. They believed that the differential pattern of gains and losses upon retests shown by the children whose initial IQ fell at the extremes of distribution was a statistical rather than an educational phenomenon. The authors intimated that the same differences would occur in test results of children attending nursery schools not claiming to improve intelligence and also in the records of children remaining at home, provided the same misuse of statistical methods occurred.

Saucier[61] replied to this attack upon the Iowa studies in 1941 when he said that psychologists are inclined to denounce research as unscientific and unreliable when its findings conflict with their traditional beliefs. This is exemplified by the reception given the Iowa studies on the IQ.

A study reported by Messenger[62] in 1940 gave the results of work done with groups of children from two distant nursery schools and control groups from each community. The groups were given identical tests and the results compared to study the effect of nursery school attendance on the mental growth of those groups attending . The investigator used

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[61] W. A. Saucier. "Lack of Scientific Attitude in Psychology." School and Society, LIII (1941), 670-71.

[62] Virginia M. Messenger. "A Longitudinal Comparative Study of Nursery School and Non-nursery School Children." (Unpublished Doctor's Dissertation, July, 1940), 270 pp.

the factor of covariance to rule out the inequality of modifying environmental factors. An attempt was made to overcome the inequality of such factors as time of testing, negativism, lack of rapport, etc. so as to meet the criticism of the opponents of the Iowa studies.

Ninety-seven children were included in this study. Forty-eight of them were nursery school children and forty-nine were non-nursery school children. The purpose of the project was to determine the influence of nursery school attendance over a period of one or two years upon the intelligence, vocabulary, information, motor achievement, social maturity, and response to failure as measured by the Kuhlmann and the Binet Scale of 1916, the Smith-Williams Vocabulary Test, the Mayghan Home Living Information Scale, the McCaskill Motor Achievement Test, the Vineland Social Maturity Scale and the Keister Failure Test.

The subjects were from the nursery school laboratories of the School of Home Economics at Oklahoma Agricultural and Mechanical College at Stillwater, Oklahoma and from the preschool laboratories of the Iowa Child Welfare Research Station in Iowa City, Iowa. In the Iowa laboratories the curriculum had been built to meet the needs of each child and provided for progressive growth as the child advanced from group to group in ability. The Stillwater group attended the nursery school where the welfare of the children is at all times a primary aim.

The intelligence tests were given at three different periods: the first was given between October 4 and October 30, 1937, at the beginning of the study; the second was given between the dates of April 9 and May 27, 1938; the final tests were given between March 2 and May 29, 1939.

The age, IQ, mid-parent education, and the intervals between the tests were held constant by the analysis of covariance[63].

When the nursery school children were compared with their respective non-nursery school groups on intelligence scores, it was found that they had significantly higher means than the non-nursery school groups at the end of the first and second years of nursery school attendance. Some evidence to the effect that although gains in IQ were made during the first and second years of nursery school attendance the IQ tended to be the same of to show a slight loss in the third year of attendance. The gains for the nursery school children consistently exceeded those of the non-nursery school groups. More of the former made gains than in the latter groups. Twenty-three of the Iowa City nursery school children had a mean IQ of 119.7 and the control group had a mean IQ of 116.7 at the beginning of the tests. At the end of the first year the nursery school children had a mean IQ of 129.6 which was a gain of 9.9 IQ points over their initial IQ mean.

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[63]Everett F. Lindquist. Statistical Analysis in Educational Research. (Boston: Houghton Mifflin, 1940), 180-207.

The final mean for the non-nursery school group in Iowa City was within 2.6 IQ points of their initial IQ mean.

Sixteen of the Stillwater nursery school children had a mean IQ of 126.6, and the control group of seventeen children not attending nursery school had a mean IQ of 120.5. At the end of the first year the nursery school group had a mean of 129.5 showing a gain of 3.1 IQ points. At the end of the second year the mean IQ was 130.1, a gain 0.6 IQ points over the first year. The final mean of the non-nursery school group at Stillwater deviated less than one point from their initial IQ mean.

The following table shows the growth pattern of the IQ's of the four groups of children:

Growth Pattern of IQ in Nursery School and Non-Nursery School Groups

Group	No.	Year	Initial IQ Mean	IQ Mean After 1 yr.	IQ Mean After 2 yr.
Ia. City Nursery School	20	1937	121.5	129.6	130.5
Ia. City Non-nursery School	22	1937	117.5	114.9	114.5
Stillwater Nursery School	16	1937	126.6	129.5	130.1
Stillwater Non-nursery School	17	1937	120.5	120.3	120.8

The author defended the findings in this study in the

following discussions. She said the the findings in this study are not explainable as "practice" and/or "regression" effects as the groups had the identical tests, and the same number of tests were given each group throughout the study. The changes in IQ are not accounted for by standardization errors because such errors would affect the groups alike. The findings are based on the results of tests which were uniform for both groups so that the pattern of change for the groups was alike. The children were allowed time to become accustomed to school before the intelligence tests were given, thus eliminating error from failure to establish rapport with them. If shyness and negativism were factors in the low scores of the non-nursery school children, this would have acted in favor of them in later scoring as they became accustomed to the examiners.

Summary:

From the foregoing reviews it may be concluded that the IQ should be used as an index of the development of mental ability rather than as a measure of fixed mental capacity.

Terman objected to the Iowa State studies on the grounds that they used the obtained IQ's as though they were always true measures of present ability, regardless of the subject's age and regardless of the limited reliability or validity of the scale employed. He said that the IQ is not

only subject to chance errors resulting from inadequate sampling of abilities, but also to numerous constant errors, including practice effects, negativism, or shyness, the personal equation of the examiner, and standardization errors in the test used.[64]

The later tests made at the Iowa State Laboratory which were reviewed in this chapter show that attempts have been made to rule out the errors referred to by Terman. They show a definite response in IQ increases to environmental stiumlation and also show how environments lacking in stimulation fail to activate mental development or even to permit the loss of IQ points. The results of these tests show that there may be great variability from the normal growth curve in mental ability and that the theories of a fixed, predetermined level of ability are false. Variations in IQ over a period of years are the response to the stimulation or inactivating influences of the environment. Theoretically, environmental influences will affect the extremes of IQ to a greater extent than the central group. Also, environment geared to stimulate the central group may tend to stimulate the lower group more than the central group and fail to arouse the abilities of those above the average.

The hereditarian and the environmentalist can whole-

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[64] Lewis M. Terman. "Personal Reactions of the Committee." Thirty-ninth Yearbook of the National Society for the Study of Education, (Bloomington, Illinois: Public School Publishing Company, 1940), p. 461.

heartedly join hands in the demand that every opportunity be given the child that his potentialities be developed to the utmost and that his sphere of mental activity be broadened to include as much as possible of the opportunities of the physical and mental universe.

CHAPTER V

MEASUREMENTS OF NUTRITIONAL STATUS

Since the primary interest in this study has to do with the part nutritional status may play in the level of mental ability, it is necessary to review the development of measurements for judging nutritional status. This will aid in the evaluation of studies in which mental ability and nutritional status were compared.

No detailed information concerning the technics of the tests used to measure nutritional conditions is given. An attempt has been made only to follow the threads of scientific information that have led to the present ideas of optimal nutritional status. The discussions have been planned to follow the periods of development in the methods used to study health and its relation to food.

The relation of food intake to bodily condition has been recognized by progressive students of science for many centuries. The early evidences, before the age of experimental method, of the recognition that food was a factor in the health and in the cure of diseases of man are interesting from a historical standpoint. In writings on many subjects are found isolated cases that illustrate the empirical use of foods to prevent or cure undesirable physical conditions. It will suffice to cite some examples of these.

Since the days of Hippocrates, 460-370 B. C., xerophthalmia, a disease now known to be due to faulty nutrition,

has been successfully treated by adding chicken livers and eel fat to the diet[65].

The experience of Cartier[66] in the winter of 1535 illustrates an empirical cure for scurvy, a disease known to be due to a vitamin deficiency. Cartier and his men were wintering in Quebec when the men began to die from scurvy. From the Indians he learned to make tea of the leaves and bark of the evergreens which cured this scurvy. It is now factual knowledge that the leaves of the evergreens are good sources of vitamin C.

An experiment in the prevention of scurvy was carried out by Lancaster[67] in 1600. He was in charge of an expedition in which several ships were taking part. On his ship only he carried lemon juice of which three spoonsful were given each of his men each day as long as it lasted. At the end of the expedition his men were the only ones who were well and able to help take the sick from the other ships.

Some of the appearances which are now recognized as signs of rickets and other nutritional deficiencies were depicted in the works of art of the early masters. The commonest disease appearing in the paintings, according to

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[65]C. M. McCay. "Seven Centuries of Scientific Nutrition." Journal of the American Dietetic Association, XV (October, 1939), p. 649.

[66]Ibid., p. 652.

[67]Ibid., p. 653.

Ruhrah[68], is that of rickets. A good example of this is seen in the child portrayed in the "Madonna and Child" painted by Dario de Trevigo in 1459[69]. In the Madonna evidences of exophthalmus are shown. From these examples it may be concluded that the people of that day had limited knowledge of the conditions of physical well-being and may have considered states that today would be called abnormal as marks of superiority.

Although the relationship of food intake to bodily condition was suggested as early as the time of the early Greeks and Romans and certainly by the thirteenth century by Roger Bacon[70], experimental work in measuring body requirements in terms of food had to wait for the development of the sciences of chemistry, physics, physiology, and biochemistry. It awaited particularly the discovery of Lavoisier[71] in the eighteenth century of the use of oxygen in the body and that foods burned or oxidized in the body. Lavoisier did a monumental work in the time allotted him, and in his experiments with animals he determined most of the facts known today concerning respiratory exchange. From the time of Lavoisier to

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[68]John Ruhrah. "Rickets and Exophthalmus." American Journal of the Diseases of Children, L (December, 1935), p. 1559.

[69]Ibid., p. 1559.

[70]McCay, op. cit., p. 649.

[71]Faith M. Williams. "Nutrition in a Eugenics Program." Journal of Heredity, XXXI (December, 1940), p. 521.

to the early part of the twentieth century the experimental work involved primarily the study of energy exchange and the metabolism in the body of carbohydrates, protein, and fat. These three food factors had been described only a few years earlier by Liebig[72] and were the only known classifications of foods at that time. Liebig classified foods according to nitrogeneous and non-nitrogeneous qualities. The nitrogeneous foods were of the plant and animal protein groups and the non-nitrogeneous foods were of fat and carbohydrates.

After Lavoisier, much of this work was done in Munich by Carl Voit and his students. This began in 1862 when Voit[73] constructed a respiration apparatus for measuring the amount of oxygen used by a subject at rest while digesting different kinds of food.

In the United States interest in the science of nutrition was aroused by the work of Atwater[74], a pupil of Voit, in 1895. Studies of the energy supplied to the average human being by foods of different kinds made it possible to study actual family diets and to estimate to what degree these diets met the energy requirements of the families. The energy requirements of children and adults were based largely upon expected body weight. These requirements were published

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[72]Lafayette B. Mendel. Nutrition: The Chemistry of Life. (New Haven, Connecticut: Yale University Press, 1923), p. 20.

[73]Ibid., p. 21.

[74]Ibid., p. 26.

in scale form in 1895 and have been successively revised since that time in the United States. Energy requirements have been summarized by H. C. Sherman and Lucy Gillett in 1917, by the Interallied Food Commission in 1918, and by the Bureau of Home Economics in 1933[75], and more recently by the Food and Nutrition Commission of the National Research Council in 1941.

Voit and Atwater [76] defined food as material that is capable of building or maintaining body tissue and of supplying energy. Voit added salts and water to the list of food essentials. He recognized that the chemical analysis of a substance does not afford a true index of its possible food value. He saw that their nutritive value must be tested by physiological experimentation[77].

Scientific research on protein, mineral, and vitamin requirements and their relationship to health was slow in appearing because of the difficulty in measuring human need of them. Systematic research on the exact nature of mineral requirements began in the United States in 1910. Hart, McCollum, Steenboch, and Humphrey[78] at the Wisconsin Experiment Station showed that there were physiological values to a ration not measureable by the then current chemical methods

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[75]Faith M. Williams, op. cit., p. 522.

[76]Mendel, op. cit., p. 26-27.

[77]Ibid., p. 29.

[78]Ibid., 30-41.

or dependent merely upon the supply of available energy. They experimented by feeding three groups of cattle on diets entirely from corn or oats or wheat plants respectively, on the growth and reproduction capacity of the cattle. A fourth group of cattle which served as a control group was fed a ration having the same chemical composition but derived from equal parts of corn, wheat, and oat products. It was found that the diets limited to wheat or to oats did not provide sufficient nutriment to support growth and satisfactory offspring. The diet of corn supplied satisfactory nutrition for growth and satisfactory offspring. When calcium was added to the oat ration the improvement was noteworthy. This series of experiments brought to light the importance of minerals in the diet.

L. B. Mendel, E. V. McCollum, H. C. Sherman, H. Steenboch, J. Goldberger and many others have worked on the dietary functions of calcium, phosphorus, and iron in human nutrition. Mendel and Osborne[79] found by experimenting with rats fed upon refined diets restricted to foods of chemically pure carbohydrates, fat and protein that there was some element that was essential to growth lacking in the diet. They found that, when butter was used in place of fat, the growth impulse returned. These experiments gave an impetus to the study of vitamins and their interrelation with minerals and other

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[79]Mendel, op. cit., 66-68.

nutrients and their relation to growth and health. Current research is now being focused on the relation of each nutrient to other factors and in turn, the influence of other factors on a given nutrient.

International knowledge of nutrition was brought to the Health Organization of the League of Nations between 1932 and 1937. One purpose of this was to prepare a chart of recommended daily food allowances for all ages. Research workers from all parts of the world met to exchange ideas on nutrition and the Commission on Nutrition of the Health Organization brought together the material on nutritional requirements about which there was general agreement at that time.

Means of measuring physical condition have not been experimented with from as early a date as the beginning of measuring energy requirements. The main criteria for judging health in the United States prior to the twentieth century were the appearance of the body and the amount of apparent vitality expressed in it. Personal judgments of robustness, energy, color, and estimates of body build were made. At about the beginning of the twentieth century, Porter in 1893, West in 1894, Boas in 1895 used the relation of weight to age to determine the nutritional status[80].

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[80]Elizabeth M. Stalnaker. "A Comparison of Certain Mental and Physical Measurements of School Children and College Students." Journal of Comparative Psychology, III (June, 1923), 181-239.

This single measure was soon objected to because the weight-age standard did not take into consideration differences in the rates of growth found between races, differences in skeletal build, or the growth impulse which causes the body to grow even when it is not well nourished. Although the growth of the body might indicate a normal state of nutrition other body needs may not be supplied and lack of vitality as well as motor and mental inefficiency may be the result. Another objection to the average weight-age standard was that there was no allowance made for the great variation in normal weight for any age.

In 1916 Baldwin[81] made a comparative study of the results of four hundred investigations on over a million children. He concluded that "the height, weight, and lung capacity of children varied according to nationality, heredity, general social status, health, sex, initial size, and stages of physiological maturity, as well as urban and rural conditions and geographical distribution."[82] He pointed out that some of the factors modifying the constancy of the results in using the standards of height-age and weight-age tables were the determination of the age of the child: i.e., whether the age should be the age of the last birthday, or

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[81]Bird T. Baldwin. "A Measuring Scale for Physical Growth and Physiological Age." Fifteenth Yearbook of the National Society for the Study of Education, Pt. I. (Bloomington, Illinois: Public School Publishing Company, 1916), 11-22.

[82]Ibid., p. 11.

the nearest birthday, with or without months, weeks, and days being taken into account; the measurement of children with or without clothing; the degree of accuracy of the measuring apparatus; and the competence of the examiners. Baldwin set up norms in terms of the coefficient of the height, weight, and lung capacity to be used as standards for comparison with all types and races of children between the ages of five and one-half and eighteen years.[83] He said that the height-weight coefficient would be the same for a large well-developed child as for the small well-developed child. Baldwin considers his norms high because the tests were made on the best developed children available who had had physical training, school medical attention, remedial treatment when necessary, and directed play. He also said that a child who falls short of these norms is not necessarily subnormal, providing his weight and breathing capacity are proportionate to his weight. These averages are not of great value in the study of individual physical development but the individual growth record of the individual is necessary.

Other investigators who worked with the ratio of height-weight as a measure of physical development were Clark, Syndenstricker, and Collins[84] in 1923. A deviation

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[83] Baldwin, op. cit., p. 15.

[84] T. Clark and others. Weight and Height as an Index of Nutrition. Public Health Report, Reprint No. 809. (Washington, D. C.: U. S. Printing Office, 1923), 22 pp.

of ten percent from the norm was allowed before the condition was considered abnormal.

Holt[85] in 1918 showed the inadequacy of the weight-age standard as a single measure of physical condition. He said that the normal variation in weight of healthy children of the same race is from ten to fifteen pounds between the ages of six and ten; and the range is from twenty to forty pounds between the ages of ten and sixteen years. He advocated the measure of height-weight relation, the measure of the annual rate of growth in height and the increase in weight, and the judgment of the general appearance of the child as indications of well-being.

In 1923 Stalnaker[86] interpreted the idea of malnutrition of the time as a "low condition of health and body substance, measureable not only by weight, height, and robustness, but also by the color of the musculature and the presence of subcutaneous fat." These together with skin texture pallor, posture, lustre of the hair, nervous habits, and evidences of vitality according to the author made up the criteria for physical examinations. The judgments of the nutritional status according to the above might vary because of its subjectiveness. If the examiner were accustomed to working with children in whom only extremes in malnutrition

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[85]L. E. Holt. "Standards for Growth and Nutrition." American Journal of the Diseases of Children, XVI (1918), 228-241.

[86]Stalnaker, op. cit., p. 222.

stand out he would probably overlook cases of slight deviation from the normal physical condition; whereas if he were working with children of normal physical condition, he would classify as poor any deviation from the accepted standard.

In the late nineteenth and early twentieth centuries the relation of vitamin deficiencies to marked physical diseases such as pellagra, scurvy, rickets, beriberi, and xerophthalmia became apparent. Where previously malnutrition was thought of as merely the amount underweight, it was recognized that there were various kinds of malnutrition, each of which needed special diagnosis and specific treatment. Animal experimentation with these diseases, their cure and prevention led to the isolation of a number of vitamins, to the discovery that some of them could be synthetically prepared, and to the realization of the interrelation of their use in the body.

Today one of the most active fields of nutritional research is that of measuring objectively and quantitatively the state of nutritional well-being. Mild deficiencies produce no definite symptoms such as scurvy and rickets and therefore go unattended and are not recognized by the average person. These deficiencies are responsible for lowered resistance, inefficiency, lack of pep, and low morale. In 1940 Williams, Mason, Wilder, and Smith[87] reported an

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[87] R. D. Williams and others. "Observations on Induced Thiamin (Vitamin B_1) Deficiency in Man." Archives of Internal Medecine, LXVI (1940), 785-799.

experiment with healthy women chosen for their record of good health. The women were fed diets similar to those that many Americans eat every day. It was somewhat but not markedly low in vitamin B_1 content. After three months one of the women had such alarming symptoms that she had to be taken off the diet and given doses of the vitamin. The other women continued with the diet for a longer period. Besides low blood pressure, capricious appetites, anemia and signs of disturbed heart action, these women became depressed, irritable, quarrelsome, and fearful. They became inefficient in their work, were confused in thought, uncertain in memory, and lacked manual dexterity.

The establishment of a good measure for the nutritional status would enable one to detect cases that fall below this standard. Then needed dietary improvement could be provided. However, it has not been possible to find a single measurement or index for the whole nutritional status; nor can one or two simple tests be used to test the adequacy of each nutrient because of their effect upon each other in their assimilation in the body. The amount required as well as the use of each nutrient in the body is somewhat dependent upon the correct balance of other nutrients. An example of this is the need for vitamins A, C, and D in the calcification of teeth and bones when proper amounts of calcium and phosphorus are ingested. Another example is the need for vitamin C in the assimilation of iron in the prevention of

anemia.

The methods used today in determining the nutritional status are dietary investigations, chemical tests on body tissue, gross and biomicroscopic examinations, physical examinations, and physiological tests. Examples of signs of malnutrition which can be observed from general appearance are: undersized body, small flabby muscles, pale mucous membrane, fatigue posture, irritability, lack of vigor, and pale or sallow skin. Dietary investigations permit a comparison of food intake with the recommended daily allowances. Chemical tests may be made to test the adequacy of iron, vitamin C, riblflavin, and other substances in the body. "Gross and biomicroscopic examinations of the conjunctiva, ocular limbus, tongue, and gums reveal all forms, degrees and stages of avitaminosis A, ariboflavinosis, aniacinosis and avitaminosis C respectively." [88] Physiological tests include roentgenograms of the bones and teeth to measure calcium, phosphorus, and vitamin adequacy; electrocardiograms measuring the heart beat as an indication of the adequacy of vitamin B_1; biophotometers and improved apparatus for measuring the adaptation of the eye to changes in light as evidences of vitamin A status.

At the present time it is necessary to use subjective and objective measurements to get as complete a picture of

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[88] H. D. Kruse M. D. "Evaluation of Nutritional Status." The Journal of the American Medical Association, CXXI, No.9. (February 27, 1943), p. 674.

the individual as possible. The chief limitation of physical measurement and clinical examination as measures of nutritional status is the failure to select those children who, while not suffering from obvious malnutrition, do have nutritional deficiency that prevents them from enjoying the abundant health and vitality that is normal for them. This borderline between obvious malnutrition and the level of nutrition which permits the fullest use of individual capacities can be measured only by objective tests. Research in this field of measurement had just begun and the whole story has been by no means told. When tests have been perfected so that complete individual inventories can be made it will be possible to measure changes in mental functioning accompanying changes in physical status. The use of the best that is known at the present time must be accepted until further advances replace the old.

CHAPTER VI

A REVIEW OF THE LITERATURE SHOWING EXPERIMENTAL EVIDENCES OF THE MODIFIABILITY OF MENTAL ABILITY THROUGH CHANGES IN NUTRITIONAL STATUS

Although many studies have been made on the relationship of food intake to physical growth and development, fewer studies have been made on the relationship of food intake to mental growth. It has been only in the past four decades that the bearing of health on educational progress has been investigated to an appreciable amount from an experimental standpoint. The first recognition that such a relationship existed was that the undernourished or malnourished child, judged according to weight, was likely to become retarded. An example of this was the investigation by Porter[89] in 1893 of 34,500 school children in St. Louis. He measured physical development by height and weight. Grade placement in relation to age was taken as a measure of mental age. He found a positive correlation between physical development and mental ability as so measured.

Boas[90] in 1895 attacked Dr. Porter's report by saying that Dr. Porter had found that mental and physical growth are correlated or depend upon common causes; not that mental

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[89] W. T. Porter. "The Physical Basis of Precocity and Dullness." Transactions of the Academy of Science of St. Louis, VI (1893), 263-380.

[90] Franz Boas. "On Dr. Porter's Investigation of Growth of Children of St. Louis." Science, I, N. S.(1895), 225-230.

development depends upon physical growth. He said that the results merely show that the children who are more vigorous accomplish a greater amount of mental work and the less vigorous or unhealthy ones will naturally be retarded in grade standing. West[91] in 1894 measured the physical and mental development of children of Worcester, Massachusetts. He used tests of specific abilities for motor ability, muscle sense, color sensitiveness, force of suggestion, discrimination, reaction time and memory time, height, weight, lung capacity, and fatigue. These were correlated with mental ability as measured by teachers' ratings of the children's natural initiative. He found a negative correlation between physical and mental measurements. He explains his variance with Porter by pointing out that Porter grouped his children so that the school grade in relation to age irrespective of the age of entrance in school or the record of attendance, was the measure of mental power. West's classification of mental ability was likely to be faulty due to the unwillingness of teachers to classify pupils as dull or poor for fear of reflection on their teaching.

An abstract of work done by Smedley[92] in 1900 on

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[91] G. M. West. "Observations on the Relation of Physical Development to Intellectual Ability." Science, IV (1894), 156-59.

[92] Elizabeth M. Stalnaker. "A Comparison of Certain Mental and Physical Measurements of School Children and College Students." Journal of Comparative Psychology, III (June, 1923), p. 186.

10,000 Chicago school children from four to twenty-one years of age in which height, weight, sitting height, lung capacity ergograph and dynamometer records were correlated with school standing, reports a positive correlation. It seemed to show that one is likely to attain his highest mental development only as he reaches the physical growth and development which nature has marked out for him.

In 1913 Bryant[93] said that the relation of malnutrition to mental defectiveness had long been given substantial recognition both in our own country and abroad in the provision of lunches in special schools for subnormal children. The calculation of percentage of mental defectives that show malnutrition has been the usual method of determining this relationship. In some cases the criterion of mental defectiveness was failure to be promoted and the factors of physical disabilities or attendance were not considered as causal in retardation.

The Bureau of Educational Experiments in New York City began classes in February 1918[94] to investigate the effect of classes in nutrition on the health and mental ability of those participating. The incentive came from Dr. William P. Emerson of Boston who was a pioneer among pediatrists in

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[93]L. S. Bryant. School Feeding. (Chicago, Illinois: J. B. Lippincott Company, 1913), p. 10.

[94]Jean L. Hunt and others. Health Education and the Nutrition Class. (New York: E. P. Dutton and Company, 1921), 281 pp.

calling attention to the serious consequences of malnutrition among school children, and in recognizing its milder states as a condition of ill-being if not of actual poor health. The children selected for their nutrition classes were first measured for height and weight. The Burk-Boas Height-Weight-Age Tables were used for their standards and those children found to be seven percent or more underweight became candidates for enrollment. Five classes were organized during the first year; a group of seventh grade, one of sixth grade, one of the first grade, one of children of the open-air classes, and one from the special Terman classes. A group of twenty fifth grade boys were selected and given a program of school feeding for purposes of comparison. Every child was given a careful examination by a physician to insure correct diagnosis and the prescription of treatment if conditions of physical disease were found to exist. The physician also looked for indications of physical defects calling for the advice of specialists. Children suffering from physical defects bearing in any way on the nutritional processes were taken to a clinic for treatment. It was difficult to secure the cooperation of the parents in this and therefore only twenty-nine percent of those needing to have their tonsils and adenoids removed had it done; sixty-three of the one hundred and five children had their teeth attended to; and the prejudice against wearing glasses kept many of those needing them from wearing glasses even after

obtaining them. By visits of the nutrition worker and the attendance of parents at the weekly sessions of the class they secured cooperation in the program of health experiences. These experiences included adequate caloric intake; the increased use of milk and cereal in the diet to replace tea and coffee and excess sweets; rest periods, and proper hours of sleep; and the building of habits of personal hygiene such as bathing and elimination. The cooperation of each child was secured and he was given booklets in which he kept a record of his food intake for 48 hours each. Individual charts were made and used as the basis of discussion for the classes. There was also discussion of nutritional standards, the value of right foods, food habits, general health habits, the bad effects of tea and coffee, and conclusions were drawn from the relative loss or gain in weight indicated on the charts. The authors point out the limitations inherent in the situation as being those of unequal physical endowment and the consequent inability of home facilities, the inaccuracy of home records, the use of faulty techniques, inadequacy of the class procedure, and the improper approach to the children. Subsequent experiments were made with changed techniques and whereas in the first experiment the results showed negative correlation between health education and gains in physical well-being the latter showed small positive correlation.

In 1919 these same workers began another experiment.

A Nutrition Class and a "Control Group" from the first grade were chosen to test the effect of health education on mental ability. These two groups were not equivalent as to physical status, economic status, racial differences, and percentage underweight. The set-up was arranged for a comparative study of growth in weight and height but did not make it easy to compare them directly for growth in mental traits. The Nutrition Group was from eight to twenty percent underweight and the Control Group was from eleven to twenty percent overweight. Physical examinations were made of the Nutrition Group but not of the Control Group. After the first weighing and measuring the latter group had no contact with the teachers until the time of the mental examinations. The Nutrition Group were given milk each day and had conferences with members of the staff each week. General intelligence ratings were obtained from the Haggerty Mental Examination, the Intelligence Quotients from the Stanford Revision of the Binet-Simon Scale, and from the teachers' ratings. Specific tests were given in the laboratory to measure the rapidity of responses and the fatigue and practice effects of various performances. Some of these were card-sorting, cancellation, action-agent association tests, rapidity of movement of the hand in single tapping, tapping on double plate, walking board, substitution, dark room experimemt, and the target test. The Nutrition Group were found to have the highest quotients and they were the ones who gained most in weight. The authors summarize

their findings thus[95]: "We do not recognize these groups as clearly enough differentiated from the standpoint of malnutrition to be representative ones for comparisons of the mental traits of the undernourished child and those of well-nourished children... In tests of general intelligence the undernourished distribute themselves similarly to children of normal height-weight-age index... The children of high intelligence gain more under the Nutrition Class procedure than those of lower scores... In a learning series the Nutrition Group were superior to the Control Group in speed and accuracy... In motor coordination and performance tests not involving uninterrupted expenditure of muscular energy... the undernourished children make normal scores according to established standards and are superior to the Control Group. In rate of voluntary movements continuous for an appreciably long period, the output for the first thirty seconds was less than that for normal children of their age." This experiment took underweight as the only criterion of malnutrition. It might have been that the Control Group were equally deficient in some other nutritional condition which did not show in height or weight.

In 1919 Sandwick[96] made a study of the relation between

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[95] Hunt, op. cit., p. 197.

[96] R. L. Sandwick. "Correlation of Physical Health and Mental Efficiency." Journal of Educational Research, I (January-May, 1925), 199-203.

mental power, as determined by an intelligence test, and comparative freedom from physical defects. The Group Intelligence Test by Rugg and Freeman was given to 423 students of the University of Chicago. The IQ's were arranged in order according to their scoring ability. Health ratings were obtained from the school nurse. It was found that the fewest and less serious defects occurred among the ablest group. Sixty percent of the low group had defective tonsils. Forty-five percent of the high group had defective teeth. This investigation supports the view that the normal child of good physical condition is also of good intellectual ability.

In 1919 Blanton[97] made a study of the mental and nervous disorders of 6500 school children between the ages of five and one-half years and fourteen years of age in Trier, Germany. His purpose was to find, if possible, what effect malnutrition had on mental ability. He selected children who were extremely nervous, mentally retarded from no apparent cause other than malnutrition, and who had failed their grades more than one year. Mental tests were given to determine the IQ so as to group the children according to levels of intelligence. The Terman Revision of the Binet-Simon Scale was used. Due to the shortage of food during and

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[97] Smiley Blanton. "Mental and Nervous Changes in Children of the Volksschulen of Trier, Germany Caused by Malnutrition." Mental Hygiene, (July, 1919), 343-386.

following the first World War, the author took it for granted that from forty to fifty percent of the children had been malnourished for a period of at least two years. The nutritional status of each child as measured by physical examination and hemoglobin test was noted as good, fair, poor, or very poor. Retardation in school was found to be due to war conditions, illnesses, malnutrition, and a combination of these. Eliminating as well as could be done all causes except those in which retardation was due to malnutrition alone, it was found that only about 2.08 percent of the whole number retarded was attributable to malnutrition alone. Illnesses due to malnutrition accounted for 2.57 percent more of the cases. Children of the dull type due to hereditary mental deficiency who might just have passed in school grades but became retarded because of malnutrition added 2.7 percent to the above. It was found by the survey that the effect of malnutrition on the physical and mental abilities depends upon two factors: on the severity of the malnutrition, and upon the mental state of the child naturally. It was upon the feeble-minded, the border-line defectives, the dull, and the children of poor and defective stock that malnutrition had its greatest effect. The percentage of poor and very poor nutritional status was almost twice as high among the defective and abnormal children as among the normal. School work dropped off because of lack of nervous energy to keep going all day; but the mental abilities of the malnourished

children who had done superior and good work in school before the war period were found, during the time of the study, to be good in the morning when they were fresh. From these observations, the author concluded that the changes in the intelligence of the children of superior ability were only apparent changes; but the changes in the lowest ten percent of those of average intelligence (the near dull) were real changes.

In order to discover just what specific mental and emotional changes are caused by malnutrition two groups of children were selected for special examination by psychological tests. The children were under twelve years of age. The first group of thirty were selected from those who, from their general behavior, their history, and the mental status of their siblings, were supposed to have an IQ of 100 or above but whose school work was average, poor, or very poor. The second group of ten children were supposed, from similar judgments, to have IQ's of 90 or above but their school work was so poor that they seemed to be border-line cases or actually defective. In these groups the family history and personal history showed nothing apart from malnutrition to account for the poor work or actual retardation. The Terman Revision of the Binet-Simon Scale was used. It was supplemented with an association test, consisting of fifty simple words implying opposites as "black", "good". This was given orally to each child and he was asked to give as quickly as

possible the opposite word "white", "bad". Learning ability was tested by counting the times a list of ten simple, unrelated words had to be repeated aloud for the child to memorize them so he could repeat them correctly in the order given. The intelligence ratings from the results of these tests placed the children in the following groups:

23 rated average intelligence — IQ 90-110
3 rated superior intelligence — IQ above 110
4 rated inferior intelligence — IQ 80-90
26 showed the degree of intelligence expected from their family and personal history, indicating that no deterioration in intelligence due to malnutrition had taken place.

The author stated[98],

> The four found to have inferior intelligence were in very poor physical condition. Malnutrition if severe enough will finally of course affect the integrity of even a good nervous system. In these cases there was a definite lowering of the normal intelligence level; part of this change we believe will be permanent...
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> A moderate degree of malnutrition in the feeble-minded and the border-line defectives and severer degrees in the dull and near-dull induce changes in the nervous system that will cause a more or less permanent lowering of the intelligence level. When such cases become well-nourished they will improve, but will never be as intelligent as they would have been had they not suffered from malnutrition....Children of good nervous stock of superior and good average intelligence can withstand malnutrition of even a serious degree extending over more than two years without any impairment of the intelligence or any definite emotional change...Children of poor nervous stock with poor or inferior intelligence suffer a general and sometimes a permanent lowering of the whole intelligence level from even a moderate

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[98] Blanton, op. cit., p. 381.

degree of malnutrition[99].

In 1922 Tredgold[100] in discussing the possibility of mental defect being caused by defective bodily nutrition and the dependence of the physical health and development of the growing child upon the quantity and quality of his food, adequate rest, fresh air, light, and warmth said,

> ...on the whole it may be said that these factors in the absence of hereditary predisposition have comparatively little causal influence...rickets is sometimes the accompaniment of mental deficiencies but I doubt whether it is ever its cause.

Naccarati and Lewy-Guinzberg in 1922[101] approached the question from a new standpoint. They studied the relation of hormones and intelligence. Their hypothesis was that the same hormones which promote skeletal growth and musculature promote also the development of sychomoter and psychosensory centers so that a correlation should exist between morphological development and the level of intelligence of the individual. They used height-weight (weight divided by height) as equivalent to the morphological index. Intelligence tests used were the Army Alpha, the Otis, and the Thorndike. The first group of fifty students were given the Army Alpha test and a correlation of 0.44 with P. E. $\pm$ 0.08

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[99] Blanton, op. cit., p.386.

[100] Alfred F. Tredgold. Mental Deficiency. (New York: William Wood, 1922), 63-64.

[101] Sante Naccarati and R. L. Lewy-Guinzberg. "Hormones and Intelligence." Journal of Applied Psychology, VI (September, 1922), 221-234.

between morphological index and IQ was found. The second group of ninety-four students were given the Otis test and a correlation of 0.15 with a P. E. ± 0.04 was found.

A study was amde in 1923 by Gesell[102] at the New York Children's Hospital of the correlation between the changes in nutritional status, based on age-height-weight index, and changes in IQ. The basis for this study was the record of forty boys from three years and eight months of age to fifteen years of age. The intervals between tests were two months to four years and two months. The means of improving the nutritional status was the care given them as residents in the home. A negative correlation of - 0.226 between changes in IQ and changes in nutritional status was attributed to the overlapping of criteria for judging nutritional condition and to the age of the subjects. The author said that mental control is conditioned by physical energy and also by social and educational adjustments. Individual adjustments to the institution must be brought about before reliable measurements can be made. The author seemed to think that hyperactivity and willfulness lowered the results of the mental tests.

Nicholls[103] in 1923 studied fifty-nine underweight

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[102] Arnold Gesell. Infancy and Human Growth. (New York: Macmillan Company, 1928), 267-271.

[103] Edith E. Nicholls. "Performance in Certain Mental Tests of Children Classified as Under Weight and Normal." Journal of Comparative Psychology, III (June, 1923), 147-181.

children, each one matched on the basis of age and intelligence with one of normal height and weight in a control group, to test the comparative results of the two groups in certain mental tests. The percent underweight of the first group was determined by the use of Wood's Tables of norms for boys and girls and found to be nine percent. The ages of the children ranged from nine to fifteen years. The IQ's were determined by using the National Intelligence Test Form One. The mental performance given included memory spans for digits, controlled association, numbered combinations, and continued work in numbered combinations. The results showed no difference in the undernourished against the normal in mental pattern as measured by number work and attention tests. But the undernourished proved inferior in tests of muscular strength and coordination. The onset of fatigue was more rapid and strength and endurance seemed to be on a lower level in the underweight group. This latter was measured by the use of the grip and endurance tests with a dynamometer.

In the same year, a three-year study of the effect of improvement in physical condition upon the intelligence and educational achievement of a group of 343 elementary school children was begun by Hardy and Hoefer[104]. The sub-

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[104]Martha Hardy and Carlyn H. Hoefer. "The Influence of Improvement in Physical Condition on Intelligence and Educational Improvement." Twenty-seventh Yearbook of the National Society for the Study of Education, Pt. I. (Bloomington, Illinois: Public School Publishing Company, 1928), 371-387.

jects for this study were chosen at random from grades 3-a, 3-b, and 4-b of twelve different schools in Joliet, Illinois. In age they ranged from eight to eleven years. No child whose IQ was under 75 or who had any physical deformities which would prevent complete anthropometric measurements were taken.

A series of examinations was given to each child, allowing as nearly as possible an exact year between tests. These consisted of a physical examination, anthropometric examinations according to Baldwin's technique, psychological tests using the Stanford Revision of the Binet-Simon Intelligence Tests and the Pintner-Patterson Performance Tests, and educational achievement tests using the Primary and Advanced Examinations of the Stanford Achievement Test, Form A.

The improvement in physical condition was judged by a physician's evaluation of the general physical condition, by the condition of the tonsils, by improvement in grip strength used as an index of general muscular condition, by change in breadth of shoulders, by increase in weight in proportion to height according to age, which was used as a rough index of the nutritional status.

The children were divided into four groups based on their physical condition judged at the time of the first and last examination in order to show improvement or lack of it.

The following four groups were used:

Group I- Good condition at the time of the first and last examinations. Designated "Good".

Group II- Fair condition at the time of the first examination and good at the time of the last examination; or poor at the first examination and fair or good at the last. Designated "Improved".

Group III- Good condition at the first examination and fair or poor at the last; or fair condition at the first examination and poor at the last. Designated "Poorer".

Group IV- Fair condition at first examination and fair at the last; or poor condition at the first examination and poor at the last. Designated "Fair or Poor".

In order to control conditions as much as possible the children chosen were within the normal range of intelligence and were on a par in school achievement. However, at the beginning of the experiment there was a tendency for the children of better physical condition to have higher ratings in intelligence and educational achievement.

The following table gives the average initial IQ's and the average gains in IQ's with their standard deviations for each group. It will be noticed that the larger gains are with the groups of better physical conditions.

Table of the Comparison of the Amount of Gain Over the Initial IQ of the Children Grouped According to General Physical Condition

Groups	No.	Intelligence Quotients Ave. Initial IQ	Ave. Gain.	S.D. of Gain
Good	145	104	4.79	± 7.56
Improved	131	105	6.72	± 7.59
Poorer	27	99	2.44	± 5.10
Fair of Poor	40	101	1.78	± 6.78

The larger gains were consistently found in the groups with better physical condition although none of the differences in gains meet the statistical standard for reliability. In only one instance was the difference even twice its standard deviation from the mean. When compared on the basis of normal expectancy in mental growth, based on initial IQ, with all factors fairly constant except that of physical condition, the initial mental superiority of those of good physical condition over those in fair physical condition, as shown in differences in mental growth rate, increased five times. There was evidence that the children whose physical condition was "good" throughout the study had a more rapid mental growth than those whose condition was "fair" throughout. A similar result was indicated in the improvement in physical condition but the results were not statistically reliable.

Abernethy[105] in 1925 made a study of 350 girls of the University of Chicago Laboratory Schools to test the correlation between physical and mental growth. The chronological age was kept constant by testing the girls at their birthday. Records were made of the height, weight, age of physiological maturation, and measures of the carpal development. Otis-Higher examination tests were given 239 of the secondary school girls and Stanford-Binet tests were given to 120

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[105] Ethel M. Abernethy. "Correlations in Physical and Mental Growth." Journal of Educational Psychology, XVI (October, 1925), 458-466.

University Elementary girls. The latter were six to twelve years of age. By dividing the girls into groups according to age and taking their mental tests at the time of their birthday, the factor of chronological age was controlled. The results showed zero or negative correlation between mental age and the ossification ratio: - 0.016 ± 0.061. Precocity of maturing failed to show significant correlation with intelligence as measured by mental tests, the correlation being + 0.021 ± 0.10. Zero or low correlation, + 0.34 ± 0.05, between height and mental age was found. The correlation between weight and mental age was about the same as for height and mental age. Records for 120 girls showed a very low negative correlation, - 0.124 ± 0.06, between dentition and mental age. The correlation between precocity of maturing and the ossification ratio was + 0.562 ± 0.067 for the fourteen year olds and + 0.467 ± 0.10 for the fifteen year olds. From these data there is no evidence that early maturing favors mental development.

The objectives of a study by Giaugue[106] in 1935 were the determination of correlations between changes in physical fitness and changes in scholastic marks and between the physical strength and the intelligence of high school boys. The subjects were students of the Lynbrook, New York High School. They were chosen because they afforded oppor-

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[106]Charles D. Giaugue. "Physical Fitness and Scholastic Standing." Research Quarterly of the American Physical Education Association, VI (March, 1935), 269-275.

tunity for study by means of physical fitness tests and scholastic ratings over a long period of time. Sixty seniors were chosen among whom were athletes, non-athletes, excellent scholars, and average pupils. Scholarship data from school records were averaged for each. Physical fitness scores were determined by the Physical Fitness Index* tests given each spring. IQ's were obtained by giving the Otis Examination Form A. Correlation coefficients were computed between pupil's scholastic marks for each year and corresponding P. F. I.'s to determine the general trend. Two groups of pupils were contrasted: those whose P. F. I.'s had increased and those whose P. F. I.'s had decreased, to see whether any specific trends were present that were hidden by the general trend. The amount of influence that outside activities may have had in reducing scholarship marks or affecting physical fitness was measured by evaluating each activity outside of school as one unit and determining the correlation between extra-curricular activities and scholarship. The IQ's and the P. F. I.'s were also correlated. The results showed that the correlation coefficient between P. F. I.'s and scholastic marks for the whole group was + 0.10. The correlation coefficient between P. F. I.'s and the scholastic marks of pupils whose P. F. I.'s had increased was - 0.15. The correlation

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*Physical Fitness Index scores are indicated by the abbreviation P. F. I.

coefficient between P. F. I.'s and the scholatic marks of those whose P. F. I.'s had decreases was ǂ 0.16. The correlation between the number of extra-curricular activities and scholastic marks was ǂ0.10. The correlation between P. F. I.'s and IQ's was - 0.25. These findings seem to indicate no relation between scholarship and physical fitness or that it is so small as to be insignificant; but the author explains this by saying that the teachers failed to stimulate or drive the pupils to use their increasing physical powers to advantage. He also points out that the scholastic ratings are unreliable because of their subjectivity.

Poull[107] in 1938 made a study of two groups of children who were under three years of age. The first group, Group I, was malnourished at the time of the first test and well nourished at the time of the second test. The second group, Group II, was well nourished during the whole period of testing. The diagnosis of nutritional condition was made by a physician. The groups were equated as to chronological age, IQ as tested by the Kuhlmann-Binet and Stanford-Binet tests, and as to interval between tests. These groups were children who had gone to the New York City Children's Home for residence. The improvement in

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[107]Louise E. Poull. "The Effect of Improvement in Nutrition on the Mental Capacity of Young Children." Child Development, IX No. I, (March, 1938), 123-26.

nutritional condition was gained during their stay in the home through the normal activities of the home. Tests were repeated at six month intervals. The results showed an average rise in IQ of ten points for Group I and no change for Group II. It was estimated that there are 99.2 chances in 100 for bettering the IQ by improvement in nutritional condition. The correlation - 0.56 between the age at the first tests and the IQ rise indicate that the younger the malnourished child when the improvement in nutrition is begun, the better the chance of improvement in IQ. The question was raised as to the irreparability of the effect of malnutrition after the age of four years because only slight gains were made after that age. The following table compares the IQ changes for the two groups according to age:

A Comparison of IQ Changes for Group I and Group II

	Group I		Group II		
Age	No. of Cases	Ave. IQ Change	No. of Cases	Ave. IQ Change	Differences in IQ Change
2	11	+ 13.0	5	+ 2.4	+ 10.6
3	15	+ 14.4	7	- 2.85	+ 17.25
4	8	+ 5.3	10	- 1.8	+ 7.1
5	0	------	8	+ 1.6	--------
6	5	+ 1.6	9	- 0.77	+ 2.37
7	2	+ .5	2	+ 1.00	- 0.5

The following table shows the IQ changes between the first and second testings according to the interval between tests. It also indicates that a period of 18 months to two years is needed to bring about the average gain in IQ from nutritional care.

IQ Change from First to Second Test

Interval between Tests	No. of Cases	Ave. IQ Change	Range
6 mo. to 11 mo.	11	+ 5.6	- 4 to + 20
12 mo. to 18 mo.	12	+ 6.8	0 to + 26
19 mo. to 25 mo.	7	+ 10.7	- 2 to + 28
26 mo. to 32 mo.	6	+ 11.3	0 to + 23
33 mo. to 5 yr.	5	+ 0.6	- 10 to + 9

Boas[108] in 1940 studied the relation between skeletal growth and development and the intelligence quotient. He recognizes the limited significane of the IQ but feels that it may be used as an expression of maturity and of intelligent use of experiences. In this sense, in a group that has had essentially the same range of experiences, it is significant. Measurements of skeletal development were made by physicians and xray films of the wrist and hands.

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[108] Franz Boas. "The Relation Between Physical and Mental Development." Science, XCIII (April, 1941), 339-42.

Deviations in IQ and in physical development from the mean of the age group of the individuals were used in estimating the correlations. An unexpectedly high correlation of + 0.47 ± 0.10 for girls and of + 0.68 ± 0.12 for boys was given. Children short for their age had an IQ markedly under the norm and the reverse was true for those whose physical development was above the norm.

Hinrichs[109] in 1941 reported a study of the correlation between health, IQ, extracurricular activities, and scholastic records. The subjects for this study were college girls of the Southern Illinois Normal University of Carbondale, Illinois. Health data were obtained from physical examinations and from history cards. These were supplemented by records of complaints and illnesses during the time of the study. Extracurricular activities included participation in one or more of approximately forty school activities. Arbitrary values were given of the degree of participation in these. Scholastic records were evaluated on the grade-point system and were classified into three groups: 1- those having less than 2.5 grade points constituting a D or E average, 2- those having 2.6 or 3.9 grade points constituting a C to C + average, and

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[109] Marie A. Hinrichs. "Some Correlations Between Health, IQ, Extra Curricular Activities, and Scholastic Record." Research Quarterly of the American Association for Health, Physical Education and Recreation, XII (May, 1941), 228-241.

3- those having 4.00 or better grade points. The data on the IQ were collected at the time of the freshman examinations. It was found that in individual instances poor health obviously was a single contributing factor in the continued poor scholarship rating. It appeared that health was not a significant factor in the IQ ratings. The results of the analysis of possible factors modifying success or failure of individual students showed that health is an important factor in modifying scholastic standing, for within each IQ range, low health scores were found among the largest proportion of students with low scholarship ratings. The following table shows a study of the causes which modify scholarship ratings of the individual students.

A Study of Causes Modifying Scholarship Rating of Individual Students

Scholarship Ratings	"A" No. Commuting		"B" No. Extra Curricular		"C" A or B and one other cause		"D" Health Score 90 or less		"E" D and one other cause		No obvious Reason for Failure	
	F*	So*	F	So	F	So	F	So	F	So	F	So
IQ 110 or Higher												
Low	3		1	7		4	11	5	10	3	4	1
Average	2		1	1	3		1	1	2	3	2	1
High												
IQ 90 to 110												
Low	12	4	10	4	12	6	47	14	27	9	17	8
Average	12	4	13	4	4	10	26	13	38	25	18	22
High	2	4	2	6	4	3	14	11	14	22	6	3
IQ less than 90												
Low	4		1	3	2	1	4	4	8		3	3
Average	1	5	7	5	4	1	19	8	9	15	9	2
High	6	4	6	7	5	4	10	5	19	12	6	10

*F- Freshman So- Sophomore

Hallowell[110] reported in 1941 a study made with 250 children under the care of the Philadelphia Children's Bureau of the Pennsylvania Children's Aid Society. The children were brought to the home from the city hospital

[110]Dorothy K. Hallowell. "Validity of Mental Tests for Young Children." Journal of Genetic Psychology, LVIII (June, 1941), 265-288.

and from other sources at very early ages. They were given psychological tests first at one, two, or three years of age and were retested at from five years to thirteen years of age. This study ran over a period of twelve years. Children under twelve months of age were given the Gesell and Merrill-Palmer Scales and a series of performance tests which were being standardized by the author. For those children of twelve months to twenty-three months of age, the Three Disc and Three Figure Formboards and Wallin Peg-boards were used in addition to the above. At twenty-four months of age tests in color matching were added. At thirty months of age the Witmer Formboard was added. In many cases, drawing tests and block building were used. The Binet Scale was given to children of thirty months and over. The results showed wide variation in IQ's on the same child at different ages. Also preschool children showing a variation on retests of more than ten IQ points improved in at least three times as many instances as they deteriorated. Of the thirty-three superior children, approximately half were similarly diagnosed on an initial test. Of the eighteen feeble-minded children, approximately ninety percent were similarly diagnosed on an initial test. Changes of ten or more IQ points were attributed to the following causes: poor health, fifteen percent; emotional factors, ten percent; environmental situations, twenty-five percent; limitations within the tests, particularly of language,

twenty percent; and undetermined causes, thirty percent. The author said that the health factor may not have entered into the variability of the IQ of this group as much as it would ordinarily because this group was under the highest type of medical service that the social agency could obtain. In analyzing the IQ changes of ten or more points, the author did not find physical reasons for the changes in more than from ten to fifteen percent of the cases. She said that health conditions if marked will interfere with mental development.

Individual cases of IQ changes reported by Hallowell showed progressive increase in IQ points as the physical condition of the child improved. Some of these cases are given in brief here.

D. M.[111] was two years old when he came to the home. He was suffering from a severe case of eczema and was physically very retarded. At twenty-five months of age and at thirty months his level of development was low. At fifty-one months the IQ, as determined by the Binet test, was sixty-six; at fifty-eight months it was seventy-two. At seventy-three months the child was living with his family. His IQ at seventy-three months was eighty-three. This case seems to be one where the mental retardation was very positively related to extreme physical condition

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[111]Hallowell, op. cit., p. 278.

which limited the possibilities for normal mental stimulation.

H. W.[112] was a badly neglected child deserted by his parents and taken into the social agency for care. At nineteen months of age his weight was that of an average twelve months old child. At twenty-four months he did not walk alone and his vocabulary consisted of fifty words used singly. At thirty-five months of age he began to use sentences. At thirty-six months of age his Binet IQ was seventy-two. At forty-nine months of age the Binet IQ was seventy-eight. The last test was given at the age of five years and eight months when his percentile rank was seventy and the Binet IQ was eighty-two. A number of factors seemed to operate in this child's development: poor early environment, retarded physical development, and inferior inherited mentality.

R. E.[113] had very inadequate early care. He was received by the social agency shortly after he was one year old. At sixteen months he had just begun to pull up onto his feet and he used just one word. At twenty-seven months he began using sentences and did exceptionally well with concrete material. At forty months the Binet IQ was 110. At sixty-eight months the Binet IQ was 112. With this

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[112] Hallowell, op. cit., p. 279.

[113] Ibid., p. 279.

child there was no pronounced physical problem; but he was frail, emotionally sensitive, and very slow in adjusting to the foster home which later adopted him.

A different approach to the study of the relation of physical condition to mental ability is found in the study of induced thiamin deficiency upon healthy women made at the Mayo Clinic in 1940 by Williams, Mason, Smith, and Wilder[114]. A description of this study may be found on page 62 of Chapter VI. Subjects for this study were eleven healthy women chosen for their previous record of willingness, lack of nerves, and ability to cooperate. After a period of reduced thiamin intake evidences of depression, irritability, confused thought and uncertain memory besides a lowering of physical condition was observed. The significance of these evidences of abnormalities resulting from the deficiency of only one nutritional essential is increased by the careful selection of the subjects for their continuous cooperation and ability to work before the restriction of thiamin.

Ochoa[115] called attention to the importance of thiamin in thought processes when he described the thought-action phenomenon as being the result of a chain of events

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[114]R. D. Williams and others. "Observations on Induced Thiamin Deficiency in Man." Archives of Internal Medecine, LXVI (1940), 785-799.

[115]Ruth Flinn Harrell. "Effect of Added Thiamin on Learning." (Unpublished Doctor's Dissertation, New York City: Columbia University, 1942), p. 3.

made possible by one of the body's enzymes, the enzyme being composed of vitamin B_1 and a protein.

In 1941 Harrell[116] said,

> If we think of learning as related to a particular food element and thus as having an economic and a biochemical side, the whole picture of learning... becomes clearer. If learning by an individual is thought of as a process among other processes where relationship and dependencies are the rule, it seems reasonable to suppose that efficient learning may depend upon certain factors of nutrition."

Harrell's hypothesis was that learning is so related to the nutrition of the body that an increase in learning ability follows an increase in thiamin (B_1) intake. The following study was made in 1941 to determine the effect of added thiamin on learning.

Data was collected on seventy-four children of the Presbyterian Orphan's Home of Lynchburg, Virginia. The ages ran from four to twenty years. Thirty-seven pairs of children participated throughout the period of testing. These were divided into a control group and an experimental group equated as nearly as possible as to ability to learn as indicated by scores on the I. E. R. Intelligence Scale CAVD, as to age, size, sex, nutritional index, school experience, and early home life. The grouping and administration of the thiamin was done so that none of the children or administrators knew in which of the groups a child belonged or which of them were receiving thiamin.

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[116]Harrell, op. cit., p. 1-2.

During the six weeks testing period, the children received periodic training in a number of different tasks to determine the comparative amount of improvement between the experimental group and the control group. The experimental group received daily 2 mg. of thiamin over and above that received in the diet. There were eighteen of these tasks adapted to the various interests and abilities of the children and were practised at least nine times by both groups at the same time and for the same length of time. Intelligence tests given were the Otis Self-Administering Tests of Mental Ability, Intermediate Examination Form A and the I. E. R. Intelligence Scale CAVD.

During the period of testing the diet, environment, motivation, and other arrangeable factors were as nearly the same for all as was possible, except for the experimental factor of 2 mg. of thiamin added daily to the diet of the experimental group.

In every one of the eighteen tasks the vitamin-fed group surpassed the control group in making gains, although they were initially similar. Retests showed that

> "the vitamin-fed group made twenty-six percent greater gain upon repetition of the I. E. R. Intelligence Scale CAVD, seventy-five percent and 253 percent greater gains upon repetition of the 4 A Audiometer tests of hearing in the right and left ear respectively."[117]

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[117] Harrell, op. cit., p. 63.

The author stated that

> "their gain is significant in Code Learning, and Underlining 4's on the one percent level, and in Reading Speed Division, Number Span, Strength of Left Hand Grip and Addition on the five percent level."[118]

The superiority of the thiamin group varied in size among the measured activities from seven to eighty-seven percent. In general the thiamin group learned more than the control group by twenty-four percent.

Dr. Tom D. Spies[119] of the University of Cincinnatti and Hillman Hospital, Birmingham in 1942 told members of the Association for Research in Nervous and Mental Diseases in New York that patients suffering from fear, irritability, and poor memory which he and his associates treated with thiamin (vitamin B_1) had been cured in from thirty minutes to twenty hours when the state of mind had been caused by lack of that vitamin in the diet. The swift recovery of the patients he reported apparently shows that the vitamin lack had kept their brains from functioning efficiently but had not damaged the brain cells. The author stated that,

> "In some cases actual damage to the brain structure might occur from the vitamin lack and then all that can be done is to supply the lacking vitamin to halt the damage and help repair the structure."[119]

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[118] Harrell, op. cit., p. 63.

[119] Tom D. Spies. (No Title), Item on Front Cover, Science Digest, (March, 1942).

In discussing the relation of vitamins to mental health, Williams[120] in 1942, said,

> It is recognized that one vitaim (niacin, formerly known as nicotinic acid), can and does cure mental derangements. One of the most disturbing symptoms of pellagra are the hallucinations, dreams and other mental symptoms. These are tremendously helped by niacin administration.
>
> People who were so "crazy" as to be totally incapacitated have been brought back to the point where they can perform the functions of a useful member of society.
>
> It should be pointed out that good diets, which means an abundant supply of vitamins, among other things, promote intellectual keenness.

Summary:

This review follows the progress of investigation into the relationship between nutritional status and mental ability from its beginning when the measures of these two factors were subjective and unscientific to the present time when the methods of investigation are becoming more and more exact and scientific.

The early studies by Porter, the Bureau of Educational Experiments of New York City, and Sandwick support the view that a normal child of good physical condition is also of good intellectual ability. Their work did not include complete tests of nutritional status. The criteris for physical well-being was either subjective or measured

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[120] R. R. Williams, News Article in the New York Times, (February 27, 1942), p. 15 column 4.

by physical examination and by weight and skeletal measurements. These are now recognized to be inadequate to get a complete picture of the nutritional status of the individual.

Blanton's work in Trier, Germany is interesting because of his approach to the subject. Using the general behavior, history, mental status of their siblings as guides to the evaluation of his subjects' normal IQ, he judged the decline in their mental ability evidenced in school work, due to the malnutrition consequent upon the ravages of the last World War. Although the methods of measurement were not scientific the results point definitely to a lowering of mental ability as malnutrition increases and a greater decline in dull or border-line defectives.

Naccarati and Lewy-Guinzberg in 1922 held the theory that there is a correlation between hormone supply and intelligence. A small positive correlation was found but no proof of the power of improvement in physical condition to improve the IQ.

Hardy and Hoefer in 1922 found more definite gains in IQ through improvement in physical condition but their results did not meet the statistical standard for reliability.

Poull's study in 1938 more nearly measured the relation of nutritional condition to IQ. She used a control group whose nutritional condition as measured by

physicians was good throughout the period of testing and an experimental group whose nutritional condition improved during the testing period. The two groups being equated in chronological age, IQ, and as to intervals between testing, the improvement in IQ would seem to be due somewhat to improvement in physical condition. However, during the study the children changed homes and the improvement in social conditions may have contributed to the improvement in IQ.

Hinrich's study in 1941 showed that of various factors modifying success or failure in school, health is of great importance, for within each IQ range low health scores were found among the largest proportion of students with low scholarship ratings.

Hallowell's report of individual cases of improvement in IQ attendant upon improved physical condition although accompanied by other stimulating influences support the conclusion that improvement in nutritional condition tends to elevate the level of intelligence.

Very few experiments in which the factors other than the IQ and nutritional status have been held constant have been reported. The work of Williams, Mason, Smith, Wilder in 1940 and of Spies in 1942 indicate a definite lowering in the expression of mental qualities in response to inadequate supply of vitamins. The work of Harrell illustrates the effect of added thiamin on learning ability.

to be that of increasing the capacity to learn. If such results follow the addition or diminuition of vitamins in the diet, who can say what will follow the administration of needed nutrients when a means of measuring total nutritional status has been discovered.

The foregoing review indicates that nutritional status does affect the IQ within the limits of inherited potentiality. The extent of its influence can not be determined until further, more completely controlled experiments are made. It will be necessary to conduct longitudinal studies of individuals in which other factors are held as constant as possible. A series of initial tests making a complete analysis of the nutritional status and of the IQ followed by a program of improvement in nutrition and interval testing to measure the changes in IQ and in nutritional status would give a picture of the effect of improvement in nutritional status on mental ability.

CHAPTER VII

CONCLUSIONS

The foregoing reviews and discussions dealt with the basic considerations which support the hypothesis that nutritional status as one unit in environment may influence the IQ of an individual or of peoples. In this concluding chapter, a correlation of the findings of the foregoing chapters will be made. This correlation should answer the question, "What are the evidences that the IQ may be modified through changes in environmental conditions, particularly through changes in nutritional conditions?"

Mental ability of which the IQ is a comparative index, is the sum total of specific abilities in which the degree of intellect is indicated by a man's power to respond to stimuli and to initiate new modes of action. It is generally accepted that the nature of mental ability is dependent upon the growth and functioning of the nervous system, which in turn is dependent upon the inherent characteristics of the individual organism and their interaction with internal and external factors of the environment. The activity of the nervous system is a chemical one and the supply and interaction of the necessary chemicals are dependent upon the nutritional status of the individual and consequently upon the food intake and its utilization in the body. It has been said that thought processes are made

possible by a body enzyme of thiamin and a protein.

Experimental evidences point to the ability of external environmental factors to modify the IQ. Especially favorable and stimulating conditions in school acted to increase the IQ of preschool attendants. Opposite results were found in situations where the stimulation was lacking.

Early attempts to measure the relationship of mental ability to nutritional status did not employ full measurements of either factor; but their findings indicate that, aside from the limits placed on the development of mental ability by such structural conditions as birth injuries, brain lesions, structural defects of the endocrine system and of the brain and nervous tissue serious enough to interfere with mental functioning, the same factors that promote physical well-being accentuate intellectual keenness and promote the realization of potential abilities.

The latest attempts to prove that factors in nutritional well-being have a bearing on mental ability have used more completely controlled conditions than formerly. Observations have been made of changes in mental ability due to changes in nutritional status where all other factors of environment were held as constant as possible. Evidences of improved mental ability following incrcreased consumption of thiamin and niacin were found. Evidences were also found that mental ability decreased when thiamin intake was reduced below normal. These evidences substantiate the

hypothesis that the IQ may be modified through changes in nutritional status. The amount of the modification will be limited by inherited potentiality. The question of the extent of the influence of nutritional status on mental ability has not been answered. The question must await further, more completely controlled experiments. Authorities differ as to the possibility of changing inherited characteristics but the conclusion seems to be justified that improved health and physical condition due to proper food intake may act as a selective factor in the development and transmission of mental characteristics from one generation to another and that through the forces of social inheritance these characteristics may become dominant.

Recommendations:

In order to measure changes in IQ due to changes in nutritional status it will be necessary to carry out longitudinal, completely controlled experiments. Subjects might be chosen in a home where environmental factors other than nutritional status could be kept constant. A series of initial intelligence tests covering as complete a sampling of abilities as possible over a preliminary period of time to get mental ability ratings should be accompanied by a complete set of examinations to determine the nutritional status of the subjects. Then remedial steps

to correct defects in nutrition should be taken. Periodic tests for improvement in nutritional status should be accompanied by intelligence testing to ascertain what changes in IQ, if any, are consequent upon changes in nutritional status.

Experienced workers should be employed both in administering and grading the intelligence tests as well as in giving tests for nutritional condition. Statistical errors should be avoided.

Correlations between changes in IQ and in nutritional status should then be made. If the correlations stand the test for statistical reliability then it could be positively stated that the IQ may be modified by changes in nutritional status and the extent of the modifiability might be estimated.

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